COSTS AND ECONOMIES OF SCALE IN FEED MANUFACTURING

MARKETING RESEARCH
REPORT NO. 815
ECONOMIC RESEARCH SERVICE
U.S. DEPARTMENT OF AGRICULTURE

PREFACE

This study is part of the Department's broad program of economic research directed toward expanding market outlets and increasing efficiency in marketing farm products. The farmer has a double interest in the feed industry's efficiency since he produces the feed ingredients and also purchases the finished product.

This is the eighth and final report resulting from research initiated by the Department in 1956. Earlier reports were: "Case Study of Labor Costs and Efficiencies in Warehousing Formula Feeds" (Mktg. Res. Rpt. 205); "Formula-Feed Warehousing Costs--A Study of Improving Efficiency in Marketing of Farm Feeds" (Mktg. Res. Rpt. 268); "Labor and Capital for Pelleting Formula Feeds" (Mktg. Res. Rpt. 463); "Labor and Capital for Mixing Formula Feeds" (Mktg. Res. Rpt. 564); "Operating Costs in Packing Mixed Feeds" (Mktg. Res. Rpt. 658); "Ingredient Handling by Feed Manufacturers--Capital and Labor Requirements" (Mktg. Res. Rpt. 727); and "Processing Feed Ingredients--Costs, Labor, and Capital Requirements" (Mktg. Res. Rpt. 731).

No report of this type is possible without the basic data supplied by individual plants and companies in the industry. The author wishes to acknowledge the individuals and their companies who cooperated in our research program. The Midwest Feed Manufacturers Association did much of the pioneering and preliminary research in cost and efficiency in feed manufacturing as part of its Feed Production School Program. Acknowledgment is due to the equipment manufacturers and their engineers who made available equipment and facility cost information which was vital to these studies.

CONTENTS

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SUMMARY

Recent technological developments and shifts in the production and consumption of mixed feeds have had marked effects on the size and operation of feed manufacturing plants. The mixed feed industry has been decentralizing manufacturing facilities, specializing production, and adding pelleting and bulk handling operations. These changes have resulted in changed labor requirements and costs of operation.

This report provides information to help feed manufacturers make investment decisions on whether to modify existing plants or to build new ones. Analyses in the report show the effects on costs of size of plant, number of shifts, hours of operation, and utilization of the rated capacity of the plant. Estimates of investment requirements and costs are included for 54 model plants--nine different operations in each of six different plant sizes ranging from 80- to 300-ton capacity for an 8-hour day and from 40- to 100-percent utilization of rated capacity. The effects of variations in the proportion of total plant output which is pelleted and/or packaged are estimated.

Total investment requirements for equipment, facility, and land for the 80-ton model are estimated at $309,730. This model (without pelleting and packaging equipment) has an investment of $14.89 per ton of output. A 300-ton plant which pellets its entire output and packages 50 percent of its output has the highest total investment--$915,155, or $11.73 per ton of output. Facility investment in all plants accounts for 40 to 50 percent of the total. Larger volume plants tend to have a higher percentage of total investment in equipment. Investment costs are greater for plants which provide for pelleting and for both packaged and bulk shipments.

Total operating costs per ton of output ranged from $7.13 to $3.04. An 80-ton operation, pelleting and packaging its entire output, had the highest cost. The lowest cost was for the 300-ton operation with no pelleted feeds and with the total output handled in bulk. Total operating costs declined about 40 percent between similar operations of the smallest and largest volume groups. Greatest reductions in total operating costs occurred as volume increased from 80 to 200 tons per 8-hour day.

Total fixed costs ranged from a high of $2.80 per ton in the 80-ton plant to a low of $1.44 in the 300-ton plant. Average fixed cost was $2.59 per ton for the 80-ton unit and $1.64 per ton for 300-ton plant. Lowest fixed costs were for plants not equipped for pelleting or packaging and highest costs were for the plants equipped to perform these functions.

Fixed costs accounted for 40 to 50 percent of total operating costs. For all bulk operations, regardless of volume size, fixed costs were a higher proportion of total costs.

Depreciation was the largest fixed cost item--ranging from a high of $1.07 per ton for the smallest to 46 cents per ton for the largest plants. Equipment depreciation accounted for 60 to 75 percent of total depreciation.

The analyses in this report give definite indications of economies of scale. Costs were synthesized for various levels of output ranging from 40 to 100 percent of capacity. As operations approached maximum capacity there was increased utilization of labor, yielding a lower labor cost per ton of output.

Total man-hour requirements for all operations ranged from 0.29 man-hour per ton in the most efficient operation to 1 man-hour per ton in the least efficient. The operations which pellet or package finished feed require considerably more labor and more initial investment than other operations in manufacturing mixed feeds, and were major factors affecting operating costs. Operations which pellet and package their total output require at least twice the man-hours per ton as the operations with no pelleting or packaging.

Three major cost categories accounted for 85 percent of the reduction in cost as levels of output rose. Labor accounted for about 38 percent, ownership for 36 percent, and administrative costs 11 percent.

When plant costs were estimated for a 16-hour day, costs per ton of output were reduced an average of 20 percent. Total cost ranged from $2.31 in the 300-ton plant to $5.76 per ton in the 80-ton plant. Almost all of the savings between the 8- and 16-hour operations were in fixed costs. Operations which either pelleted or packaged output appeared to have smaller savings.

COSTS AND ECONOMIES OF SCALE IN FEED MANUFACTURING

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INTRODUCTION

A primary question facing feed manufacturing firms is the optimum size of manufacturing facility that would minimize the total feed cost per ton to the farmer. The optimum plant size depends on economies in manufacturing as well as other important factors. Management must analyze and carefully consider the characteristics of livestock and poultry production within the area that a given plant will serve. These factors will have considerable impact on the size and type of feed mill as well as its distribution system.

The mixed feed industry has grown rapidly and has changed markedly since World War II, in response to many economic and technical developments. Large numbers of farmer-feeders have shifted from home-produced to commercial feeds. They have insisted on buying improved-quality mixed feeds made possible by advances in animal nutrition. Today, most formula feeds contain between 15 and 25 ingredients, microingredients, and drugs. Nutritional research has shown how livestock and poultry production can be increased per unit of feed by the addition of certain ingredients, such as vitamins, antibiotics, hormones, and drugs.

Strong economic pressures on agriculture have made farmer-feeders more aware of production costs. Feed costs account for about two-thirds of the livestock and poultry production costs. Farmers are demanding low-cost feeds with more free services from the manufacturer. These services include free advice on feeding and production, free delivery, credit, custom-prepared feeds, and quantity discounts.

At the same time, changes in the location of major livestock and poultry producing areas in the United States forced the mixed feed industry to move also. This geographic movement toward major feed-consuming areas and increasing demands on the industry for more services contributed to the decentralization of the mixed feed industry. The trend from distant large-scale mills with extensive distribution organizations to local, demand-oriented feed mills supplying local production units has been quite significant.

During this period of change, developments in technology have contributed to pressures on the industry to alter plant design, equipment, and operations. New technology and equipment have made possible tremendous improvements in plant operating efficiency since World War II. The advancements in technology

and competitive pressure are quite evident in the location shift of feed manufacturing facilities.

Relocating feed manufacturing facilities into the major agricultural production and consuming areas offers potential cost reductions by making possible (1) the operation of highly efficient, specialized feed mills, (2) direct distribution of feed to the production units, and (3) lower transportation costs for grain and other feed ingredients.

METHODOLOGY

This study is concerned only with plant facilities and operating costs involved in manufacturing mixed feeds. It does not consider optimum plant location, which would require examination of ingredient purchasing and distribution patterns and costs.

Feed manufacturing includes a number of basic operations. An earlier study showed that several of these were being performed inefficiently and offered information on great opportunities for improvement. 1/ These were researched first in detail to provide pertinent data to plant managers. The overall project was approached in this manner, since the industry recognized that the most urgent need was for cost and efficiency studies on these inefficient processes. Previous studies have been made of all operations in order of their importance. This report updates these studies and combines them into the "total package" of feed manufacturing.

The economic-engineering approach was used to construct 54 model feed plants. This approach required determining various physical input-output relationships for each step in the manufacturing process. Standardized costs were applied to physical input requirements to derive cost functions for the model plants.

These basic model mills were constructed to provide guidelines for labor standards, equipment costs, and other costs incurred in manufacturing livestock and poultry feeds. Basic input and output data for these models were obtained from over 200 feed manufacturers in 30 States by mail surveys and personal interviews conducted during recent years. These data have been updated to reflect 1967 levels of operating efficiency within feed plants. Other pertinent information on equipment costs, utility rates, and wage rates for 1967 necessary to complete the analyses was obtained from both industry and Government sources. Investment costs and operating costs for these models represent average costs for the United States. Plants in a particular area may have higher or lower costs, depending upon representative costs for the locality. Model plants in six volume categories are used to illustrate the relationships which exist in plants operating at various levels of capacity.

1/ Midwest Feed Manufacturers Association Feed Prod. School Proc., Kansas City, Mo. Nov. 1956.

A uniform set of cost center definitions was used with each survey so managers could supply data for their plants on a comparable basis. Following is a brief summary of the activities included in each cost center:

I. Ingredient receiving center

Begins as the railcar or truck is located at the unloading point.

Includes receiving, storing, and handling to the first point of rest, all incoming raw materials, including empty bags and other supplies.

Includes the work of turning or otherwise reconditioning all ingredients and returned bags; ends as the materials are placed either in the holding bins or in the receiving warehouse.

II. Grain processing center

Begins with removing the grain to be processed from the grain storage bins.

Includes all the work entailed in grinding, crimping, and cracking, and moving grain to and from the processing equipment.

Ends as the processed grain is in either mixing bins or ingredient storage bins.

III. Mixing center

Begins with the removal from storage of the ingredients used in mixing.

Includes the movement of all materials into the mixing area, weighing bulk and trace ingredients, opening and dumping bagged ingredients, and the actual mixing of the feed, including the addition of liquids through liquid blenders. Preparation of pre-mixes is also done here. All mixed feed is moved from this center into holding bins or to the scales for packing.

Ends as the mixed feed comes to rest in holding bins at the next cost center.

IV. Pelleting center

Begins with the mixed feed located in holding bins over the pellet machines and high molasses feed from the molasses blender. Pelleting includes all of the work necessary to operate equipment such as feeders, extruders, coolers, scalpers, dusters, crumble rolls, and making the die changes.

Ends as the pellets or crumbles are moved into holding bins either for packing or for bulk delivery.

V. Packing center

Begins with the mixed feed, pellets, or crumbles in the holding bins over the packers, or the holding bins over the molasses blender for making dairy or high molasses feeds.

Includes weighing, packing, and sewing bags for all finished feeds. Obtaining empty bags from storage is also included.

Ends as the bags leave the sewing machine.

VI. Warehousing center

Begins after the bags of finished feed leave the sewing machine ready for loading on handtrucks or pallets or the bulk feed is placed in the storage bins. All movement of finished feeds from the sewing machine through warehouse to and including loading of the railcars and trucks is included. Also, the work involved in resacking materials from broken bags, coopering railcars, and checking outbound shipments is included.

Ends when the railcars or trucks have been loaded and are ready for transport.

VII. Maintenance center

Includes all regular and preventive maintenance work throughout the mill. Also includes the time of the watchman and special cleaning crews that perform cleaning operations over and above those performed by the regular production workers. Major building repairs and highway truck maintenance are not included.

VIII. Plant foreman

Plant foreman's or superintendent's time spent in production operation.

BASIC MILL OPERATIONS

Use of a cost center breakdown in the analysis of individual plant operations permits examination of individual segments of the total manufacturing process and the location of inefficient areas. Cost center analyses require a knowledge of the general layout and functioning of the feed plant and of its components. Figure 1 illustrates the physical flow of basic feed ingredients and the mixed feed through the various operations in formula feed mills.

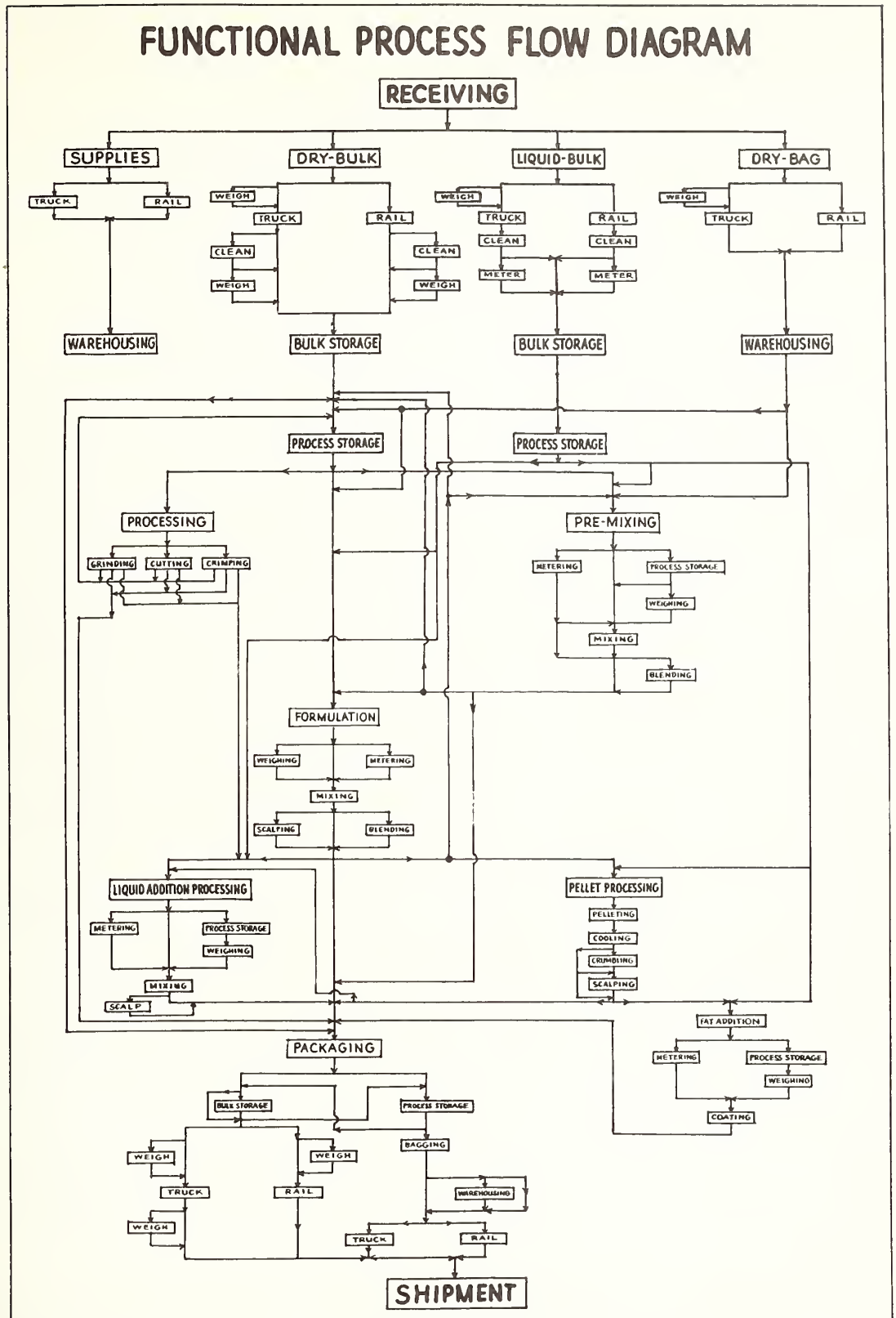

FUNCTIONAL PROCESS FLOW DIAGRAM
RECEIVING
SUPPLIES
DRY-BULK
LIQUID-BULK
DRY-BAG
TRUCK
RAIL
WEIGH
CLEAN
METER
WAREHOUSING
BULK STORAGE
PROCESS STORAGE
PROCESSING
GRINDING
CUTTING
CRIMPING
PRE-MIXING
METERING
WEIGHING
MIXING
BLENDING
FORMULATION
SCALPING
LIQUID ADDITION PROCESSING
SCALP
PELLET PROCESSING
PELLETING
COOLING
CRUMBLING
SCREENING
FAT ADDITION
COATING
PACKAGING
BAGGING
SHIPMENT

Figure 1

Receiving.--The model mills handle both rail and truck delivery of grains and ingredients. Some ingredients, such as meat, fishmeal, limestone, fat, molasses, and pre-mixes, are usually delivered by truck.

Dry ingredients are received either in bulk or in bags. Bulk ingredients are delivered by rail in either box or hopper cars. Hopper cars are discharged directly into a receiving conveyor or pit, which is more efficient than receiving from boxcars that require both more time and additional labor to unload. Bagged ingredients are delivered by either rail or truck. The bags are loaded on pallets and moved by forklift truck to storage in the warehouse.

Heated liquid fat and molasses are delivered by tank truck and pumped directly from the truck into heated storage tanks in the mill.

Bulk grain and other ingredients are conveyed from the receiving pit by a drag conveyor to a bucket elevator, then elevated and gravity-fed through a scalper cleaner and a recording weigh scale. Both nonmetallic foreign material and tramp metal are removed during cleaning. After cleaning and weighing, the material is elevated a second time and sent through a distributor to holding bins or to horizontal conveyors which convey the ingredients into storage bins.

Shelled corn and other grains are stored in the large holding bins adjacent to the main building. Soybean meal, the largest volume soft ingredient, is also stored in outside bins. Other soft bulk ingredients are stored in workbins over the mill. The ingredient storage capacity of the workbins is assumed to about equal the volume required for 5 days of mill operation at designed capacity.

Processing.--Shelled corn and other grains are ground before mixing with other feed ingredients. Whole grains are conveyed from the holding bin to the hammermill and ground. Ground ingredients are elevated to workbins by a pneumatic system. The ground grains are then blended with other ingredients in the mixing center.

Mixing.--The mixing cost center consists of (1) moving bagged ingredients to the mixing center, (2) weighing, (3) mixing, (4) conditioning, and (5) conveying the mixed feed to the next operation.

From overhead storage bins, bulk ingredients go to the batch scale by means of feeder conveyors. Feeder conveyors are used in many mill installations, since large quantities must be moved quickly to keep the feed mixers filled. Quantities of various ingredients are fed into the hopper from central control panels operated manually or electrically.

Bagged ingredients are brought as needed from warehouses to the central mixing area where the bags are opened, weighed, and dumped into the mixer. Heated stabilized animal fat is metered directly into the mixer from the storage tank and its flow is controlled either automatically or manually.

Mixing time depends on the feed formulation, characteristics of the mixer, and the ingredients mixed. Mixing time for horizontal-type mixers (as used in the models) varies from 3 to 5 minutes and may be controlled manually or by an automatic timing device.

After mixing, the feed is dropped into a surge bin and is conveyed to a bucket elevator. A surge bin reduces the total time required at this cost center. The mixed feed is elevated and passes through a cleaner and conditioner to remove any foreign material and to break up lumps. The finished feed then goes to a storage bin either for pelleting or for bagging.

Pelleting.--Pelleting starts with the mash feed being fed into the pellet mill conditioner. At this point, steam is added to the mash and then forced through the pellet die by the rollers. The continuous flow of hot pellets from the machine moves by gravity into a vertical cooler. Pellets flow directly to the scalper where unpelleted mash is removed and then conveyed back to the pellet mill for repelleting.

Pelleted feed is then conveyed to the storage bin, where it is either shipped in bulk, or packaged for distribution.

Packing.--Finished feed flows by gravity from the storage bin through an automatic trip scale set to deliver 50 or 100 pounds, depending on the size of package desired. The feed is bagged, sewn, and either moved to warehouse storage or loaded directly on a truck or a railcar for shipment.

It is most important in the packing operation for the worker to check periodically to see that the feed does not contain any foreign material or look off-color. The operator must check weights to see that the customer is getting the quantity specified on the bag and that the overweight, if any, is within satisfactory limits. The bagged feed is then moved into the warehouse on a pallet by a forklift.

Warehousing.--A limited amount of bagged feed must be held as inventory to fill customers' orders. The warehouse model provides storage for a 5-day requirement of most finished feeds as determined by past inventory trends. The finished-feed inventory takes into account typical orders expected during the next 5-day period. The large-volume formula feeds are maintained at a higher level so orders can be promptly filled. Several batches of each type of formula feeds should be mixed consecutively and warehoused so there will be less time lost in formula changeover.

MODEL MILLS

The model mills analyzed in this study were developed from manufacturing systems based on current mill engineering designs. The models are based on six different levels of designed capacity. Costs of operating each size model at different levels of capacity utilization are estimated. Production volume of each model mill is determined by the volume-to-weight ratio of the finished feeds.

Model mill volume sizes are based on the capacity of the mixing center per 8-hour day. Six volume sizes are used: 80, 100, 150, 200, 250, and 300 tons of finished feed per day. Annual output for these models is estimated to be the daily output times 260 working days. Further analysis is made by varying the output for each of the six model sizes from 40 to 100 percent of

capacity. Mill operations are further varied by the quantity of total mill output that is pelleted and the quantity of output that is bagged.

The study analyzes basic operations and costs for six volume sizes with nine variations in each. In effect, they are different operations and may be considered as 54 separate plants. Each has its own set of requirements for equipment and facilities, and cost estimates would be based on these requirements.

The nine types of operations are each designated by a letter (A, B, C, etc.) which is used throughout the report. For example, a particular size and type of mill is referred to throughout the report as model 80-A, 150-E, etc.

The following tabulation gives the designation for each type of operation, regardless of volume, according to whether all, half, or none of the mash feed is pelleted or bagged:

Operation	Mash	Pelleted	Bagged
	Percent	Percent	Percent
A	100	--	--
B	100	--	50
C	100	--	100
D	--	100	--
E	--	100	50
F	--	100	100
G	50	50	--
H	50	50	50
I	50	50	100

Specifications for Model Mills

Specifications used in constructing model mills were obtained from past survey data updated with current information from trade associations, mill designers, equipment suppliers, mill managers, and unpublished sources. The economic-engineering approach was used, and the basic specifications common to all models are described below. With these established, operational standards and costs may be calculated and costs compared.

Type of operation.--The models are assumed to be operating one 8-hour shift a day, 260 days a year. Production or output of the models is based on the weight per cubic foot of the feed ingredients and that of the finished product. For example, dairy feed may weigh 20 to 28 pounds per cubic foot while poultry feed might be between 38 and 42 pounds. This means that on the average a cubic foot of poultry feed would weigh about 1-2/3 times as much as a cubic foot of dairy feed or a mixed feed of similar density. This variation

makes it possible for a system to move a greater tonnage of a heavier, more dense feed than of a lighter, less dense feed even though the total cubic feet of material moved would be equal.

An average of 37 pounds per cubic foot of finished feed is used to estimate output of models in this study. This assumes that the feeds manufactured are not predominantly poultry nor livestock feeds. In a specialized poultry operation, it would be possible to increase output over the average by 10 to 15 percent. Likewise, in a plant manufacturing cattle feeds, the output would be reduced by that amount.

With a diversified feed manufacturing operation there is always a question of formula changes. A maximum of 14 formula changes per 8-hour shift was assumed in the models. If this number were reduced, greater output could be realized, but if the changes were increased, output would suffer.

Equipment.--The kind, type, size, and number of equipment items required for each model mill are synthesized from input-output relationships and manufacturers' equipment specifications. Each model has the manufacturing equipment and potential to produce most formulations in specific forms and quantities during an 8-hour day. Equipment has been divided into seven categories, six of which are concerned with the primary manufacturing operations. A miscellaneous group includes equipment used by a number of operations. The equipment cost represents an average delivered price of the equipment ready for installation. The equipment installation costs for each model are estimated as separate cost items.

•Receiving equipment includes conveyors, bucket elevators, and cleaning, weighing, and other equipment for handling incoming ingredients from the receiving point to storage bins.

•Grinding equipment includes conveyors to move grain from storage to the hammermills and pneumatic conveyors for moving the ground material to the workbins. Distributor turnheads and conveyors located on the bin floor direct and convey the materials into the proper workbins.

•Mixing equipment consists of feeder conveyors, hoppers, horizontal mixers, and weighing and mixing control devices. There is a considerable difference between the 80-ton model mixing equipment and that for the 300-ton model. The basic difference is the increased automation in the larger mill.

•Pelleting requires pellet mills, pellet coolers, graders, conveyors, and other miscellaneous equipment. (It is the most expensive process as far as equipment costs are concerned.)

•The boiler size for each model mill is based on estimated steam requirements. Most of the steam used in a mill is required for pelleting. Boiler sizes vary from 40 hp. in the 80-ton model up to 250 hp. for the 300-ton model. These boilers are high-pressure systems with pressure reduced at the pellet mill. This type of system enables the pellet-mill operator to get the maximum amount of steam with the correct amount of moisture necessary for the best pelleting.

Miscellaneous equipment in the models includes items not assignable to any particular cost center, such as air compressor, remote motor controls for the entire mill, personnel elevator, boiler, and so forth.

Facilities.--A number of variables determine construction costs. Some of the main ones are: Location with reference to transportation, topography, and soil conditions of the site; type and size of building constructed; building materials used; and local building codes. All model mills are assumed to be located on fairly level sites with access to both a railroad and highway. Soil conditions are assumed to be satisfactory to support buildings with normal concrete footings. Buildings are constructed of a combination of masonry and steel sheeting. All buildings have been designed to provide for future expansion.

The mill building which houses the workbins and the equipment area is tall in relation to its width and length, permitting the maximum use of gravity flow for moving materials.

The first floor and basement of the mill house the major items of equipment. These vary and depend largely on the size of the mill, the technology used, and the physical plant layout. The mixing panelboard, the scale hopper, the scale, and packing equipment are located on the first floor of the mill.

Above the first floor is the workbin area. Below each of the workbins is a conveyor to carry material from the bin hopper to the hopper scale above the mixer.

Each model mill has a finished-goods warehouse adjoining the mill building for low-cost handling, and efficient storage and shipment of bagged finished feeds. The size of the warehouse for each model is governed by the type of operation performed; that is, the size increases as the percentage of output bagged is increased and stored. Warehouses are of steel construction set on a concrete base. A construction cost rate of $7 per square foot is used to estimate the warehouse investment for each of the models.

An office is included for the administrative personnel and staff. The amount of office space required for each model is primarily a function of the number of personnel. Space requirements are estimated and a cost of $10 per square foot is used to determine investment.

The sizes of the boiler house and maintenance shop are determined by the size of each model. Substantial quantities of steam are required for the manufacturing of pellets, and heating liquids used in feed mixing, as well as the heating necessary in certain sections of the mill. The cost of the boiler room, the stack, and the shop is estimated at $8 per square foot.

Outside grain storage is used in all model mills. Each mill has outside storage capacity for at least 15 days' supply of whole grain and soybean meal. Outside storage bins are bolted steel tanks located next to the mill building and the rail siding.

Each mill requires a rail siding to spot the loaded cars of ingredients as well as the empty cars waiting to be loaded. The linear feet of siding required were determined by estimating the maximum number of cars on the track daily. A rate of $15 per linear foot of track was used to estimate the cost of the siding.

Each model handling finished feeds in bulk has outside holding bins with capacity equivalent to at least 1 day's output of bulk formula feed. The welded steel bins are erected on a steel frame over a weighing unit and are located next to the mill. In the larger models a platform scale is used to weigh the feed; however, for the smaller mills, a traveling weigh-hopper is used under the bin hopper. The weighing of the bulk feed is handled by workers within the mill by remote control. Both types of machine print a ticket for each weighing as each order of formula feed is placed in the bulk truck.

Acreage requirements for the model mills are determined by the land occupied by the mill buildings plus adequate space for truck and rail movements. Models were assumed to require a minimum of 2 acres for the smaller mills and up to 4 acres for the larger mills. An assigned cost of $5,000 per acre is assumed to be reasonable, although site costs will vary considerably.

Labor.--In the models, labor is classed as production, maintenance, or supervisory. An average hourly wage rate of $2.55 is used for production workers. 2/ Supervisors' hourly wage rate is assumed at $3.10 per hour and maintenance labor rate at $2.85 per hour. This study also assumes that a worker's 8 hours can be spent in more than one cost center. Likewise, a worker may be performing routine or preventive maintenance and supervisory work during part of his 8 hours of work.

The maintenance labor category is assigned to time needed for daily equipment oiling and maintenance as well as for a preventive maintenance program. Also included is time required for normal repairs incurred in daily operations of equipment.

Labor standards used in estimating costs were derived from updating in-plant cost standards according to the most recent survey data and information from feed manufacturers and feed equipment manufacturers.

It should be kept in mind that these labor standards are constructed under the production and equipment conditions specified for each model. If changes occur in physical conditions, production requirements, or equipment of the mill, labor costs may also change. However, these figures are fairly dependable standards in most mills where a full range of formula feeds is manufactured at normal capacity. Therefore, it is possible in some mills, particularly the specialized ones, to exceed this level of efficiency.

To best use labor, new plants are usually designed to have some excess mill capacity. This allows a temporary increase of output to compensate for that lost during shutdowns or emergency maintenance. It also allows increasing

2/ Data from: Employment & Earnings Statistics, U. S. Dept. Labor (Monthly) 1966.

the labor force and using the excess mill capacity to fill increased requirements for feed before having to increase the capital investment by building a new plant.

Depreciation.--Depreciation is the cost of wear and obsolescence. Rates for determining annual depreciation costs for the models are developed from information provided by mills, equipment manufacturers, and the Internal Revenue Service guide. 3/

Obsolescence appears to be the primary consideration in the establishment of equipment and depreciation rate. Although some in the industry take a longer or shorter depreciation period, a 15-year depreciation period for equipment is assumed to be average. Equipment for all model mills has been depreciated by the straight-line method over a 15-year period. Some of the equipment in the models may have a 10- to 25-year estimated useful life, but overall, the 15-year average seems realistic.

The survey data showed that older mill buildings and facilities have been depreciated over a longer period of time than is used for newer mills. Many of these facilities are rendered obsolete by the numerous developments occurring in feed mill equipment. The industry is aware that obsolescence of facilities may become an even more important factor in the future. The facility depreciation uses the straight-line method over 25 years. The Internal Revenue Service provides a guide whereby facilities in the feed industry could be depreciated from 25 years to a maximum of 50 years.

It is possible to make a good case for allocating somewhat higher depreciation charges for plants operating more than one shift a day. However, annual hours of operation were not considered to be of major importance in making cost estimates for the models. Such depreciation is likely to be small in relation to time depreciation and obsolescence for equipment, particularly in a mill with an adequate preventive maintenance program.

Interest.--Annual interest cost is estimated by applying 3 percent, or one-half the nominal interest rate of 6 percent, times the total capital investment in equipment and facilities. In addition, a rate of 6 percent is used on the nondepreciable land investment.

Interest is an imputed cost which does not take into account the source of investment capital. Although business firms show interest as an expense if paid to outside agencies, true capital cost includes an interest allowance on the owners' equity.

Taxes.--Property taxes vary considerably among States and among the communities within a State. In some States, taxes may be levied on all property while in others, the equipment would be exempt. Also, communities in most States establish the percentage of total value to be assessed.

A tax rate of 1 percent of initial investment is used in the models. Actual rates were obtained through personal interviews of feed plants in the

3/ Depreciation--Guidelines and Rules. U. S. Internal Revenue Service Publication No. 456 (7-62), 56 pp. 1962.

Midwest. Rates ranged from about 2 percent of replacement cost for mills within city limits down to about 0.80 percent of replacement cost of mills in rural areas.

Insurance.--Numerous factors affect the cost of insurance for a feed manufacturing facility. Those having to do with the plant included building materials, types of electric motors, type of fire prevention equipment in the mill, and location of the facility with regard to local fire protection. The last item is a very important factor in rate determination.

A rate of 1 percent or $1 per $100 investment in buildings and equipment is used to estimate the annual cost of insurance.

Utilities.--Utilities include electricity, water, and fuel. Electricity costs are estimated for the average machine operating time required in the feed manufacturing process with normal power use by equipment, at the rate of 2 cents per kilowatt-hour. The straight-line method is used, since previous studies have shown total cost for electricity increases in direct proportion to increase in tonnage output of feed.

Water consumption is estimated by using 100 gallons per day for each employee's personal use and 4.5 gallons for each boiler horsepower-hour. An average rate for water purchased was assumed to be 25 cents per 1,000 gallons, which includes the higher cost for the initial charge or minimum quantity used.

Fuel costs, based on steam requirements in all parts of the mill, are estimated at the rate of 13 cents a gallon for fuel oil. This should be a realistic average for all sizes.

Other costs.--In addition to labor, ownership, administration, supervision, and utilities costs, there are other cost items to be considered.

Annual costs for maintenance and repair for both equipment and facilities account for about 7 percent of the total original investment. Cost of equipment repairs and parts includes the cost of replacing parts for equipment that has failed because of wear as well as the services hired by the mill to make such repairs. Equipment repair costs are variable because they occur as a result of wear and use. Building maintenance costs are included because facilities must be kept in good repair, but this cost is minor compared with that for equipment maintenance.

Mill supplies, as another category, may include lubricants, housekeeping supplies, and a number of other miscellaneous items and materials. A flat cost of 10 cents per ton of output is used for all models.

Miscellaneous cost includes many items, such as feed registration and analysis fees, legal fees, travel expenses for management personnel, office supplies, telephone, and other minor costs. A per ton estimate is used for these costs for each model, ranging from 25 cents for the smaller volume models to 18 cents for the 300-ton mill.

Investment in Equipment and Facilities

Total mill investment for equipment and facilities in the models ranges from $299,730 for model 80-A to $895,155 for model 300-E (table 1). Land costs would increase total costs for the smaller models to $309,730 and for the larger ones to $915,155.

Investment per ton of annual capacity ranges from $14.89 for the 80-ton models to $11.73 for the 300-ton models. A significant reduction is possible if the models are operated 16 hours a day for the year.

The equipment and facilities costs shown in table 1 were synthesized from input-output relationships developed from information gathered in surveys of feed manufacturers and from recommendations made by equipment manufacturers. A detailed breakdown of equipment and facilities costs for all operations in the six models is shown in appendix A, tables 17-22.

Installation costs are estimated separately (table 1). Total cost of equipment is about one-third of the total investment. Equipment and installation costs per unit of output tend to be slightly greater in the smaller models. Cost of the larger capacity equipment does not increase in direct proportion with the increased capacity.

There are some differences in equipment and mill costs between each of the models, primarily because of the basic model requirements. For example, more space is required with an increase in tonnage received, manufactured, and stored in bulk bins or warehouses. Operations G, H, and I, which pellet 50 percent of the output, have more equipment than operations A, B, and C. Likewise, operations which have both bulk and bagging must have a separate line of equipment for each function. These are the main reasons for equipment and facility cost variations.

Building costs are primarily a function of space required. This space increases as the operation becomes more varied and as output is increased. A minimum percentage of volume of inventory is stored by all models, regardless of size; however, storage space increases as operations within the mill increase.

Building categories are: Mill building and workbins, outside ingredient storage, finished feed storage, warehouse, boiler room, and office. Representative construction costs are used for each type of building in the feed mill complex.

Total cost for all buildings ranges from $147,850 for model 80-A to $339,750 for model 300-H (table 1). Operation A in all models requires the least total space because it is the simplest type of operation--all mash feed in all bulk form. Operation H is about the most complex, with both mash and pelleted output, and half of it bagged. More equipment as well as more storage space is required for operation H.

Facility costs for these steel-construction models are estimated to be about 20 percent less than the same design constructed wholly of concrete.

Table 1.--Equipment, facility, and installation costs for all model feed mills

Model size and cost	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
80 tons:									
Equipment	84,720	98,320	96,370	116,850	130,450	128,500	108,920	122,520	120,570
Facilities	147,850	160,130	156,530	156,010	165,290	161,690	160,190	167,610	164,010
Installation	67,160	80,050	75,700	90,800	103,100	98,750	84,860	98,340	93,990
Total	299,730	338,500	328,600	363,660	398,840	388,940	353,970	388,470	378,570
100 tons:									
Equipment	102,120	117,220	114,920	151,575	166,675	164,375	126,220	141,320	139,020
Facilities	164,230	175,550	171,550	167,380	177,700	173,700	178,350	187,730	183,730
Installation	77,060	91,660	86,460	114,090	129,090	123,890	95,010	110,210	105,010
Total	343,410	384,430	372,930	433,045	473,465	461,965	399,580	439,260	427,760
150 tons:									
Equipment	122,175	139,175	136,475	179,575	196,575	193,875	150,253	167,253	164,553
Facilities	198,130	216,630	212,630	201,860	218,360	214,360	209,860	226,360	222,360
Installation	92,090	109,140	103,840	135,190	151,040	145,740	113,230	129,280	123,980
Total	412,395	464,945	452,945	516,625	565,975	553,975	473,343	522,893	510,893
200 tons:									
Equipment	172,280	186,680	180,830	237,230	251,630	245,780	218,180	232,580	226,730
Facilities	227,540	255,080	250,080	230,740	246,390	242,390	233,690	259,690	255,690
Installation	129,640	145,065	135,915	178,315	193,840	184,690	163,890	179,715	170,565
Total	529,460	586,625	566,825	646,285	691,860	672,860	615,760	671,985	652,985
250 tons:									
Equipment	190,100	214,300	211,250	269,000	293,200	290,150	247,900	272,100	269,050
Facilities	278,180	304,180	293,680	278,060	302,060	291,560	292,960	316,410	305,910
Installation	142,350	166,075	158,275	202,000	225,325	217,525	186,450	209,575	201,775
Total	610,630	684,555	663,205	749,060	820,585	799,235	727,310	798,085	776,735
300 tons:									
Equipment	201,200	226,650	224,150	294,300	319,750	317,250	260,600	286,550	284,050
Facilities	313,590	340,140	330,340	314,050	333,580	323,780	320,880	339,750	329,950
Installation	151,600	171,975	168,575	221,150	241,825	238,425	196,350	216,925	213,525
Total	666,390	738,765	723,065	829,500	895,155	879,455	777,830	843,225	827,525

However, this relationship will vary with facility size, storage capacity, location, and competitive conditions in the two types of construction. Concrete construction costs become smaller per cubic foot as the facility size increases in total capacity and height.

Facility costs account for between 40 and 50 percent of total cost of equipment and facility (table 1). Facility costs in relation to total cost for operation A in all models tend to be higher than for other operations. A detailed breakdown of plant costs is provided in appendix A.

Maximum land costs used are $10,000 for the smaller models and $20,000 for the larger models. Plant location is assumed to be satisfactory for construction and is accessible to rail and highway. Utilities are available at a nominal charge.

Operating Costs

Operating costs do not include costs of ingredients, transportation, feed sacks, and other items which would be considered in a plant location analysis.

Operating costs for the models are shown in tables 2 to 7. Costs have been categorized as either fixed or variable and are discussed in the order that they appear in the tables. Table 8 shows depreciation costs.

Fixed

The major portion of fixed costs is ownership costs. The initial investment in equipment and facilities is spread over their useful or productive life. Depreciation is a prime example of this cost. Other fixed costs are for administrative personnel, taxes, insurance, and interest on investment. In the shortrun, these costs are fixed and do not vary with the output.

Depreciation.--Depreciation for the models ranges between 46 cents per ton of feed produced to $1.07 per ton (table 8). Operation E of all models tends to have the highest cost and operation A the lowest cost. Operation E of each model is about 35 to 45 percent more than operation A, when equipment and facilities are not depreciated separately.

Equipment depreciation comprises 60 to 75 percent of the total. Facility depreciation increases from 10 to 23 percent between the lowest and the highest cost operations in each model.

Taxes.--Taxes for the models ranged from 9 to 19 cents per ton. The assumed tax rate was 1 percent of initial investment. The larger the model, the less variation there was between operations.

Insurance.--A rate of $1 per $100 investment in buildings and equipment was used to estimate the annual cost of insurance. The cost for the models varied from a high of 19 cents per ton in the 80-ton size to 9 cents per ton for the 300-ton size.

Table 2.--Operating cost per ton for 80-ton model feed plants, by operation

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation:									
Equipment	.49	.57	.55	.67	.75	.73	.62	.71	.69
Building	.29	.31	.30	.30	.32	.31	.31	.32	.32
Administrative	.74	.74	.74	.74	.74	.74	.74	.74	.74
Taxes	.14	.17	.16	.18	.19	.19	.17	.19	.18
Insurance	.14	.17	.16	.18	.19	.19	.17	.19	.18
Interest	.46	.52	.50	.56	.61	.59	.54	.61	.58
Total	2.26	2.48	2.41	2.63	2.80	2.75	2.55	2.76	2.69
Variable:									
Labor:									
Production	.76	1.36	1.73	.98	1.59	1.96	1.08	1.71	2.09
Maintenance	.28	.28	.28	.28	.32	.32	.32	.32	.32
Supervisory	.31	.35	.35	.35	.35	.35	.39	.39	.39
Utilities	.34	.34	.34	.72	.72	.72	.55	.55	.55
Maintenance and repairs	.53	.60	.58	.66	.70	.68	.63	.69	.68
Supplies	.10	.10	.10	.10	.10	.10	.10	.10	.10
Miscellaneous	.25	.25	.25	.25	.25	.25	.25	.25	.25
Total	2.57	3.28	3.63	3.34	4.03	4.38	3.32	4.01	4.38
Grand total	4.83	5.76	6.04	5.97	6.83	7.13	5.87	6.77	7.07

Table 3.--Operating cost per ton for 100-ton model feed plants, by operation

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation:									
Equipment	.46	.54	.52	.68	.76	.74	.57	.65	.63
Building	.25	.27	.26	.26	.27	.27	.28	.29	.28
Administrative	.68	.68	.68	.68	.68	.68	.68	.68	.68
Taxes	.13	.15	.14	.17	.18	.18	.15	.17	.17
Insurance	.13	.15	.14	.17	.18	.18	.15	.17	.17
Interest	.42	.47	.45	.52	.57	.55	.48	.53	.51
Total	2.07	2.26	2.19	2.48	2.64	2.60	2.31	2.49	2.44
Variable:									
Labor:									
Production	.60	1.29	1.57	.93	1.50	1.74	.82	1.59	1.84
Maintenance	.23	.26	.23	.26	.26	.26	.26	.26	.26
Supervisory	.25	.31	.31	.31	.31	.31	.31	.31	.31
Utilities	.30	.30	.30	.66	.66	.66	.49	.49	.49
Maintenance and repairs	.49	.66	.54	.62	.68	.66	.57	.63	.60
Supplies	.10	.10	.10	.10	.10	.10	.10	.10	.10
Miscellaneous	.25	.25	.25	.25	.25	.25	.25	.25	.25
Total	2.22	3.17	3.30	3.13	3.76	3.98	2.80	3.63	3.85
Grand total	4.29	5.43	5.49	5.61	6.40	6.58	5.11	6.12	2.29

Table 4.--Operating cost per ton for 150-ton model feed plants, by operation

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation:									
Equipment	.37	.43	.41	.54	.60	.58	.45	.51	.49
Building	.20	.22	.22	.21	.22	.22	.22	.23	.23
Administrative	.59	.59	.59	.59	.59	.59	.59	.59	.59
Taxes	.11	.12	.12	.13	.15	.14	.12	.14	.13
Insurance	.11	.12	.12	.13	.15	.14	.12	.14	.13
Interest	.34	.38	.37	.42	.46	.45	.38	.43	.41
Total	1.72	1.86	1.83	2.02	2.17	2.12	1.88	2.04	1.98
Variable:									
Labor:									
Production	.60	1.23	1.49	.71	1.38	1.63	.80	1.47	1.72
Maintenance	.19	.23	.23	.21	.23	.23	.21	.23	.23
Supervisory	.21	.25	.25	.23	.25	.25	.23	.25	.25
Utilities	.23	.23	.23	.60	.60	.60	.41	.41	.41
Maintenance and repairs	.40	.44	.44	.49	.55	.54	.44	.51	.48
Supplies	.10	.10	.10	.10	.10	.10	.10	.10	.10
Miscellaneous	.22	.22	.22	.22	.22	.22	.22	.22	.22
Total	1.95	2.70	2.96	2.56	3.33	3.57	2.41	3.19	3.41
Grand total	3.67	4.56	4.79	4.58	5.50	5.69	4.29	5.23	5.39

Table 5.--Operating cost per ton for 200-ton model feed plants, by operation

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation:									
Equipment	.38	.43	.41	.53	.57	.55	.49	.53	.51
Building	.18	.19	.19	.18	.19	.19	.18	.20	.20
Administrative	.52	.52	.52	.52	.52	.52	.52	.52	.52
Taxes	.10	.12	.11	.12	.14	.13	.12	.13	.13
Insurance	.10	.12	.11	.12	.14	.13	.12	.13	.13
Interest	.33	.36	.35	.39	.43	.41	.38	.41	.40
Total	1.61	1.74	1.69	1.86	1.99	1.93	1.81	1.92	1.89
Variable:									
Labor:									
Production	.54	1.18	1.45	.63	1.25	1.52	.72	1.35	1.62
Maintenance	.20	.21	.21	.21	.23	.23	.21	.23	.23
Supervisory	.23	.23	.23	.23	.25	.25	.23	.25	.25
Utilities	.20	.20	.20	.60	.60	.60	.40	.40	.40
Maintenance and repairs	.38	.42	.41	.45	.51	.48	.44	.48	.47
Supplies	.10	.10	.10	.10	.10	.10	.10	.10	.10
Miscellaneous	.19	.19	.19	.19	.19	.19	.19	.19	.19
Total	1.84	2.53	2.79	2.41	3.13	3.37	2.29	3.00	3.26
Grand total	3.45	4.27	4.48	4.27	5.12	5.30	4.10	4.92	5.15

Table 6.--Operating cost per ton for 250-ton model feed plants, by operation

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	-Dollars-								
Fixed:									
Depreciation:									
Equipment	.34	.40	.38	.48	.54	.52	.45	.50	.48
Building	.17	.20	.19	.17	.20	.18	.18	.21	.19
Administrative	.52	.52	.52	.52	.52	.52	.52	.52	.52
Taxes	.09	.11	.11	.12	.13	.13	.11	.13	.12
Insurance	.09	.11	.11	.12	.13	.13	.11	.13	.12
Interest	.30	.35	.33	.37	.41	.39	.37	.40	.38
Total	1.51	1.69	1.64	1.78	1.93	1.87	1.74	1.89	1.81
Variable:									
Labor:									
Production	.44	1.02	1.29	.52	1.09	1.37	.56	1.18	1.45
Maintenance	.21	.23	.23	.21	.23	.23	.23	.23	.23
Supervisory	.22	.25	.25	.22	.25	.25	.25	.25	.25
Utilities	.18	.18	.18	.59	.59	.59	.38	.38	.38
Maintenance and repairs	.34	.41	.39	.43	.48	.46	.43	.47	.44
Supplies	.10	.10	.10	.10	.10	.10	.10	.10	.10
Miscellaneous	.18	.18	.18	.18	.18	.18	.18	.18	.18
Total	1.67	2.37	2.62	2.25	2.92	3.18	2.13	2.79	3.03
Grand total	3.18	4.06	4.26	4.03	4.85	5.05	3.87	4.68	4.84

Table 7.--Operating cost per ton for 300-ton model feed plants, by operation

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	-Dollars-								
Fixed:									
Depreciation:									
Equipment	.30	.35	.34	.44	.49	.48	.39	.44	.43
Building	.16	.19	.18	.16	.18	.17	.17	.19	.17
Administrative	.52	.52	.52	.52	.52	.52	.52	.52	.52
Taxes	.09	.10	.09	.11	.12	.11	.10	.11	.11
Insurance	.09	.10	.09	.11	.12	.11	.10	.11	.11
Interest	.28	.32	.30	.34	.38	.36	.32	.36	.34
Total	1.44	1.58	1.52	1.68	1.81	1.75	1.60	1.73	1.68
Variable:									
Labor:									
Production	.41	.90	1.19	.47	.95	1.25	.51	1.02	1.33
Maintenance	.19	.21	.21	.19	.21	.21	.21	.22	.21
Supervisory	.21	.23	.23	.21	.23	.23	.23	.24	.23
Utilities	.18	.18	.18	.59	.59	.59	.38	.38	.38
Maintenance and repairs	.33	.38	.35	.41	.45	.43	.38	.44	.40
Supplies	.10	.10	.10	.10	.10	.10	.10	.10	.10
Miscellaneous	.18	.18	.18	.18	.18	.18	.18	.18	.18
Total	1.60	2.18	2.44	2.15	2.71	2.99	1.99	2.58	2.83
Grand total	3.04	3.76	3.96	3.83	4.52	4.74	3.59	4.31	4.51

Table 8.--Depreciation cost per ton for model feed mills

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
80 tons:									
Equipment cost	151,880	178,370	172,070	207,650	233,550	227,250	193,780	220,860	214,560
Deprec. per ton	.49	.57	.55	.67	.75	.73	.62	.71	.69
Facility cost	147,850	160,130	156,530	156,010	165,290	161,690	160,190	167,610	164,010
Deprec. per ton	.29	.31	.30	.30	.32	.31	.31	.32	.32
Total	.78	.88	.85	.97	1.07	1.04	.93	1.03	1.01
100 tons:									
Equipment cost	179,180	208,880	201,380	265,665	295,765	288,265	221,230	251,530	244,030
Deprec. per ton	.46	.54	.52	.68	.76	.74	.57	.65	.63
Facility cost	164,230	175,550	171,550	167,380	177,700	173,700	178,350	187,730	183,730
Deprec. per ton	.25	.27	.26	.26	.27	.27	.28	.29	.28
Total	.71	.81	.78	.94	1.03	1.01	.85	.94	.91
150 tons:									
Equipment cost	214,265	248,315	240,315	314,765	347,615	339,615	263,483	296,533	288,533
Deprec. per ton	.37	.43	.41	.54	.60	.58	.45	.51	.49
Facility cost	198,130	216,630	212,630	201,860	218,360	214,360	209,860	226,360	222,360
Deprec. per ton	.20	.22	.22	.21	.22	.22	.22	.23	.23
Total	.57	.65	.63	.75	.82	.80	.67	.74	.72
200 tons:									
Equipment cost	301,920	331,745	316,745	415,545	445,470	430,470	382,070	412,295	397,295
Deprec. per ton	.38	.43	.41	.53	.57	.55	.49	.53	.51
Facility cost	227,540	255,080	250,080	230,740	246,390	242,390	233,690	259,690	255,690
Deprec. per ton	.18	.19	.19	.18	.19	.19	.18	.20	.20
Total	.56	.62	.60	.71	.76	.74	.67	.73	.71
250 tons:									
Equipment cost	332,450	380,375	369,525	471,000	518,525	507,675	434,350	481,675	470,825
Deprec. per ton	.34	.40	.38	.48	.54	.52	.45	.50	.48
Facility cost	278,180	304,180	293,680	278,060	302,060	291,560	292,960	316,410	305,910
Deprec. per ton	.17	.20	.19	.17	.20	.18	.18	.21	.19
Total	.51	.60	.57	.65	.74	.70	.63	.71	.67
300 tons:									
Equipment cost	352,800	398,625	392,725	515,450	561,575	555,675	457,950	503,475	497,575
Deprec. per ton	.30	35	.34	.44	.49	.48	.39	.44	.43
Facility cost	313,590	340,140	330,340	314,050	333,580	323,780	320,880	339,750	329,950
Deprec. per ton	.16	.19	.18	.16	.18	.17	.17	.19	.17
Total	.46	.54	.52	.60	.67	.65	.56	.63	.60

Interest.--Interest on investment is a major fixed cost in each model, varying from a high of 61 cents per ton in the 80-ton group down to 28 cents a ton in the 300-ton models. Interest and equipment depreciation costs tend to be very close in many of the models' operations. Interest accounts for about one-fourth of the total fixed cost in all models. A comparison of interest costs between the operations in a given model shows that operation E tends to have an interest cost 35 percent greater than operation A, which has the lowest cost.

Administrative costs.--A number of administrative duties must be performed in the daily operations of any feed manufacturing plant. Some of these are general management, ingredient purchasing, determining formulas, quality control, typing, and bookkeeping. These costs vary considerably among plants, depending on the organizational structure and services received from a home office if the plant is controlled by a parent firm.

This study has assumed a fixed administrative cost per ton for a particular size model, regardless of variation in operations. The 80-ton model has the highest cost, 74 cents per ton, which decreases as models increase in size; the 300-ton plant has a cost of 52 cents per ton.

Variable

Variable costs as used in these models include such items as mill labor, utilities, equipment maintenance and repairs, supplies, and miscellaneous expense items which are a function of plant output.

Labor inputs and costs.--A most important trend in the feed industry in recent years has been the reduction in labor cost. More and more mills are being automated. This has reduced production cost and opportunities for human error. In some of the more specialized automated mills, labor requirements are reduced to 0.20 man-hour per ton.

Production and maintenance time for all models ranges from a low of 0.23 to a high of 0.89 man-hour per ton (table 9). Production and supervisory time combined ranges from 0.29 to 1.00 man-hour per ton. Operation A in all models has the fewest man-hours per ton and labor cost. The highest cost operations are F and I. Packing, in any model, increases the cost considerably over an all-bulk operation like that of A, D, and G.

Models 80-F and 80-I require a maximum of 10 full-time employees in the mill. Models 300-F and 300-I require 24 workers. Models 80-A and 100-A have the fewest--five full-time workers. Eleven men are needed in model 300-A. A more detailed breakdown on labor requirements is in appendix tables 24-29.

Annual production labor cost in the models ranges from $15,912 to $98,124 (table 10). Operation A in each model size has the lowest production labor cost. The cost is 41 cents per ton in model 300-A and 76 cents a ton in model 80-A (table 10). Operation I is the highest cost operation in all model groups; its cost ranges from $1.33 a ton in 300-I to $2.09 in 80-I. Operation A production labor cost tends to lie between 30 and 40 percent of the high-cost operation I.

Table 9.--Man-hours: Total, production and maintenance, and per ton for an 8-hour day in model feed plants

Item	Method of operation								
	A	B	C	D	E	F	G	H	I
80 tons:									
Production & maintenance	32	47	63	39	55	71	38	54	70
Per ton	.40	.59	.79	.49	.69	.89	.48	.68	.88
Total	40	56	72	48	64	80	48	64	80
Per ton	.50	.70	.90	.60	.80	1.00	.60	.80	1.00
100 tons:									
Production & maintenance	32	54	70	46	62	78	38	62	78
Per ton	.32	.54	.70	.46	.62	.78	.38	.62	.78
Total	40	64	80	56	72	88	48	72	88
Per ton	.40	.64	.80	.56	.72	.88	.48	.72	.88
150 tons:									
Production & maintenance	46	76	100	53	84	108	53	84	108
Per ton	.31	.51	.67	.35	.56	.72	.35	.56	.72
Total	56	88	112	64	96	120	64	96	120
Per ton	.37	.59	.75	.43	.64	.80	.43	.64	.80
200 tons:									
Production & maintenance	57	97	129	65	104	136	65	104	136
Per ton	.29	.49	.65	.33	.52	.68	.33	.52	.68
Total	72	112	144	80	120	152	80	120	152
Per ton	.36	.56	.72	.40	.60	.76	.40	.60	.76
250 tons:									
Production & maintenance	62	108	148	70	116	156	68	116	156
Per ton	.25	.43	.59	.28	.46	.62	.27	.46	.62
Total	80	128	168	88	136	176	88	136	176
Per ton	.32	.51	.67	.35	.54	.70	.35	.54	.70
300 tons:									
Production & maintenance	68	114	162	76	122	170	74	121	170
Per ton	.23	.38	.54	.25	.41	.57	.25	.40	.57
Total	88	136	184	96	144	192	96	144	192
Per ton	.29	.45	.61	.32	.48	.64	.32	.48	.64

Table 10.--Production labor: Man-hours per day and annual cost per ton in model feed plants

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
80 tons:										
Hours per day	Man-hours	24	39	55	31	46	62	29	45	61
Annual cost	Dollars	15,912	25,857	36,465	20,553	30,498	41,106	19,227	29,835	40,443
Cost per ton	Dollars	.76	1.36	1.73	.98	1.59	1.96	1.08	1.71	2.09
100 tons:										
Hours per day	Man-hours	24	45	62	37	53	69	29	53	69
Annual cost	Dollars	15,912	29,835	41,106	24,531	35,139	45,747	19,227	35,139	45,747
Cost per ton	Dollars	.60	1.29	1.57	.93	1.50	1.74	.82	1.59	1.84
150 tons:										
Hours per day	Man-hours	36	64	88	42	72	96	42	72	96
Annual cost	Dollars	23,868	42,432	58,344	27,846	47,736	63,648	27,846	47,736	63,648
Cost per ton	Dollars	.60	1.23	1.49	.71	1.38	1.63	.80	1.47	1.72
200 tons:										
Hours per day	Man-hours	43	82	114	50	88	120	50	88	120
Annual cost	Dollars	28,509	54,366	75,582	33,150	58,344	79,560	33,150	58,344	79,560
Cost per ton	Dollars	.54	1.18	1.45	.63	1.25	1.52	.72	1.35	1.62
250 tons:										
Hours per day	Man-hours	44	88	128	52	96	136	48	96	136
Annual cost	Dollars	29,172	58,344	84,864	34,476	63,648	90,168	31,824	63,648	90,168
Cost per ton	Dollars	.44	1.02	1.29	.52	1.09	1.37	.56	1.18	1.45
300 tons:										
Hours per day	Man-hours	48	92	140	56	100	148	52	98	148
Annual cost	Dollars	31,824	60,996	92,820	37,128	66,300	98,124	34,476	64,974	98,124
Cost per ton	Dollars	.41	.90	1.19	.47	.95	1.25	.51	1.02	1.33

Maintenance labor cost is considered separately because over the short run this cost can be less than that used in the models. However, most feed manufacturers realize that a good preventive maintenance program is most economical over the long run.

Maintenance labor requirements range from 8 hours per day in several operations in the 80-ton model series to 23 hours per day in one operation in the largest model (table 11). In many operations of the six model sizes, maintenance may require less than 8 man-hours per day. In the 150-ton group, maintenance requirements range from 10 to 12 hours per 8-hour day. This means one man full time, plus another for 2 to 4 hours a day.

Maintenance labor cost ranges from $5,928 in the smallest model to a maximum of $17,043 in the largest (table 11). Looking at it from another view, maintenance costs the feed manufacturer between 19 and 32 cents a ton annually. This cost bears a definite relationship to the total cost of equipment in the models.

Supervisory, like maintenance, labor in these models ranges from 8 hours to 23 hours per day (table 12).

Annual supervisory costs range from $6,448 in models 80-A and 100-A to $18,538 in model 300-H (table 12). Supervision costs between 21 and 39 cents a ton of finished feed. It is possible to have a lower per ton cost in smaller plants, since overall size is not the main factor in cost of supervision.

Total mill labor costs range from 81 cents per ton in 300-A to $2.80 a ton in 80-I (table 13). Production labor accounts for 50 to 75 percent of all mill labor cost. Maintenance and supervisory labor are each responsible for between 12 and 25 percent of the total.

In all models, operation A has the lowest labor costs and operations F and I have the highest costs. The high-cost processes, pelleting and packing, greatly affect cost of production. Operation A in all size categories has about 50 percent of the labor costs of operation I.

Utilities.--Utility cost is minor in all operations except the full pelleting operations D, E, and F. In operations A, B, and C, total utility costs range from 18 to 34 cents per ton of output (table 14). Electricity accounts for about 75 percent of this cost. In operations D, E, and F, where all feed is pelleted, the cost of electricity ranges from 59 to 72 cents per ton, accounting for one-half to two-thirds of the utility costs. Fuel oil cost makes up most of the remaining portion. Water cost is insignificant in all operations.

In operations G, H, and I, utility costs range from 38 to 55 cents per ton (table 14). Electricity again is the largest item and makes up about two-thirds of the total cost. Table 15 shows consumption of electricity and its cost for all operations of the six models.

Utility costs for pelleting are two to three times greater than for all other operations.

Table 11.--Maintenance labor: Man-hours per day, annual cost and cost per ton in model feed plants

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
80 tons:										
Hours per day	Man-hours	8	8	8	8	9	9	9	9	9
Annual cost	Dollars	5,928	5,928	5,928	5,928	6,669	6,669	6,669	6,669	6,669
Cost per ton	Dollars	.28	.28	.28	.28	.32	.32	.32	.32	.32
100 tons:										
Hours per day	Man-hours	8	9	8	9	9	9	9	9	9
Annual cost	Dollars	5,928	6,669	5,928	6,669	6,669	6,669	6,669	6,669	6,669
Cost per ton	Dollars	.23	.26	.23	.26	.26	.26	.26	.26	.26
150 tons:										
Hours per day	Man-hours	10	12	12	11	12	12	11	12	12
Annual cost	Dollars	7,410	8,892	8,892	8,151	8,892	8,892	8,151	8,892	8,892
Cost per ton	Dollars	.19	.23	.23	.21	.23	.23	.21	.23	.23
200 tons:										
Hours per day	Man-hours	14	15	15	15	16	16	15	16	16
Annual cost	Dollars	10,374	11,115	11,115	11,115	11,856	11,856	11,115	11,856	11,856
Cost per ton	Dollars	.20	.21	.21	.21	.23	.23	.21	.23	.23
250 tons:										
Hours per day	Man-hours	18	20	20	18	20	20	20	20	20
Annual cost	Dollars	13,338	14,820	14,820	13,338	14,820	14,820	14,820	14,820	14,820
Cost per ton	Dollars	.21	.23	.23	.21	.23	.23	.23	.23	.23
300 tons:										
Hours per day	Man-hours	20	22	22	20	22	22	22	23	22
Annual cost	Dollars	14,820	16,302	16,302	14,820	16,302	16,302	16,302	17,043	16,302
Cost per ton	Dollars	.19	.21	.21	.19	.21	.21	.21	.22	.21

Table 12.--Supervisory: Man-hours per day, annual cost, and cost per ton in model feed plants

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
80 tons:										
Hours per day	Man-hours	8	9	9	9	9	9	10	10	10
Annual cost	Dollars	6,448	7,254	7,254	7,254	7,254	7,254	8,060	8,060	8,060
Cost per ton	Dollars	.31	.35	.35	.35	.35	.35	.39	.39	.39
100 tons:										
Hours per day	Man-hours	8	10	10	10	10	10	10	10	10
Annual cost	Dollars	6,448	8,060	8,060	8,060	8,060	8,060	8,060	8,060	8,060
Cost per ton	Dollars	.25	.31	.31	.31	.31	.31	.31	.31	.31
150 tons:										
Hours per day	Man-hours	10	12	12	11	12	12	11	12	12
Annual cost	Dollars	8,060	9,672	9,672	8,866	9,672	9,672	8,866	9,672	9,672
Cost per ton	Dollars	.21	.25	.25	.23	.25	.25	.23	.25	.25
200 tons:										
Hours per day	Man-hours	15	15	15	15	16	16	15	16	16
Annual cost	Dollars	12,090	12,090	12,090	12,090	12,896	12,896	12,090	12,896	12,896
Cost per ton	Dollars	.23	.23	.23	.23	.25	.25	.23	.25	.25
250 tons:										
Hours per day	Man-hours	18	20	20	18	20	20	20	20	20
Annual cost	Dollars	14,508	16,120	16,120	14,508	16,120	16,120	16,120	16,120	16,120
Cost per ton	Dollars	.22	.25	.25	.22	.25	.25	.25	.25	.25
300 tons:										
Hours per day	Man-hours	20	22	22	20	22	22	22	23	22
Annual cost	Dollars	16,120	17,732	17,732	16,120	17,732	17,732	17,732	18,538	17,732
Cost per ton	Dollars	.21	.23	.23	.21	.23	.23	.23	.24	.23

Table 13.--Total labor costs per ton: Production, maintenance, and supervisory, in model feed plants

Cost item by size of model	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
80 tons:									
Production	.76	1.36	1.73	.98	1.59	1.96	1.08	1.71	2.09
Maintenance	.28	.28	.28	.28	.32	.32	.32	.32	.32
Supervisory	.31	.35	.35	.35	.35	.35	.39	.39	.39
Total	1.35	1.99	2.36	1.61	2.26	2.63	1.79	2.42	2.80
100 tons:									
Production	.60	1.29	1.57	.93	1.50	1.74	.82	1.59	1.84
Maintenance	.23	.26	.23	.26	.26	.26	.26	.26	.26
Supervisory	.25	.31	.31	.31	.31	.31	.31	.31	.31
Total	1.08	1.86	2.11	1.50	2.07	2.31	1.39	2.16	2.41
150 tons:									
Production	.60	1.23	1.49	.71	1.38	1.63	.80	1.47	1.72
Maintenance	.19	.23	.23	.21	.23	.23	.21	.23	.23
Supervisory	.21	.25	.25	.23	.25	.25	.23	.25	.25
Total	1.00	1.71	1.97	1.15	1.86	2.11	1.24	1.95	2.20
200 tons:									
Production	.54	1.18	1.45	.63	1.25	1.52	.72	1.35	1.62
Maintenance	.20	.21	.21	.21	.23	.23	.21	.23	.23
Supervisory	.23	.23	.23	.23	.25	.25	.23	.25	.25
Total	.97	1.62	1.89	1.07	1.73	2.00	1.16	1.83	2.10
250 tons:									
Production	.44	1.02	1.29	.52	1.09	1.37	.56	1.18	1.45
Maintenance	.21	.23	.23	.21	.23	.23	.23	.23	.23
Supervisory	.22	.25	.25	.22	.25	.25	.25	.25	.25
Total	.87	1.50	1.77	.95	1.57	1.85	1.04	1.66	1.93
300 tons:									
Production	.41	.90	1.19	.47	.95	1.25	.51	1.02	1.33
Maintenance	.19	.21	.21	.19	.21	.21	.21	.22	.21
Supervisory	.21	.23	.23	.21	.23	.23	.23	.24	.23
Total	.81	1.34	1.63	.87	1.39	1.69	.95	1.48	1.77

Table 14.--Utility costs per ton of output for model feed plants by operation

Cost item by size of model	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
80 tons:									
Electric	.27	.27	.27	.45	.45	.45	.36	.36	.36
Fuel oil	.07	.07	.07	.26	.26	.26	.18	.18	.18
Total 1/	.34	.34	.34	.72	.72	.72	.55	.55	.55
100 tons:									
Electric	.23	.23	.23	.40	.40	.40	.32	.32	.32
Fuel oil	.07	.07	.07	.26	.26	.26	.16	.16	.16
Total 1/	.30	.30	.30	.66	.66	.66	.49	.49	.49
150 tons:									
Electric	.18	.18	.18	.35	.35	.35	.25	.25	.25
Fuel oil	.05	.05	.05	.25	.25	.25	.16	.16	.16
Total	.23	.23	.23	.60	.60	.60	.41	.41	.41
200 tons:									
Electric	.15	.15	.15	.35	.35	.35	.25	.25	.25
Fuel oil	.05	.05	.05	.25	.25	.25	.15	.15	.15
Total	.20	.20	.20	.60	.60	.60	.40	.40	.40
250 tons:									
Electric	.14	.14	.14	.35	.35	.35	.25	.25	.25
Fuel oil	.04	.04	.04	.24	.24	.24	.13	.13	.13
Total	.18	.18	.18	.59	.59	.59	.38	.38	.38
300 tons:									
Electric	.14	.14	.14	.35	.35	.35	.25	.25	.25
Fuel oil	.04	.04	.04	.24	.24	.24	.13	.13	.13
Total	.18	.18	.18	.59	.59	.59	.38	.38	.38

1/ May not add to totals because cost of water is included.

Maintenance and repairs.--The cost of maintenance, replacement parts for equipment, and services hired by the mill to make repairs is a variable cost. It is assumed to be 7 percent of the total investment cost.

Cost per ton decreases with increased plant size. Model 80-E has the highest cost--70 cents per ton (tables 2-7). Operation E has the highest investment in each model size and therefore a high cost for maintenance and repairs is expected. Operation A, on the other hand, has the smallest investment and this cost item is low. The lowest cost for maintenance and repairs, 33 cents per ton, occurs in model 300-A.

Supplies.--A fixed cost of 10 cents per ton is made for all models and all operations. The supplies include housekeeping materials, oils and lubricants, and other materials used in the plant. Estimated costs of supplies were obtained from survey data.

Miscellaneous.--This item includes many costs associated with management and administrative duties. Survey data were used as a basis for estimating per ton cost for the models. All operations in a volume size are assumed to incur the same miscellaneous costs. This cost ranges from 25 cents per ton in the 80-ton plant to 18 cents per ton in the 300-ton plant (tables 2-7).

Total

Total operating costs vary widely with changes in mill operations as well as with the volume of mixed feed produced. Costs varied from a high of $7.13 a ton in the 80-ton group down to $3.04 for a 300-ton plant (table 16).

There are definite economies of scale with increased plant output. As the model size increases from 80 to 300 tons, the total operating cost per ton declines between 35 and 40 percent for most operations (table 16).

Average costs range from about $6.20 per ton for all 80-ton models to $4.03 per ton for the 300-ton size group. Over 70 percent of the cost difference occurs in the models producing 200 tons a day or less. In most situations, plants producing over 300 tons per day would experience only a slight cost reduction.

Table 16 summarizes the total operating costs for all models and operations. Total operating costs could be reduced about 20 percent for operation A in all models if these plants specialized in producing a single line, such as broiler feed.

Fixed cost for most operations of the models accounts for 40 to 50 percent of total operating costs. The percentage is higher for operations A, D, and G, the all-bulk operations, than for other operations. The other operations require more manpower, which raises the level of variable costs.

Many factors influence the total cost of operating feed mills. The major cost item is wages and salaries. Other factors include volume of operation, variation in production, and percentage of capacity utilized. The models as

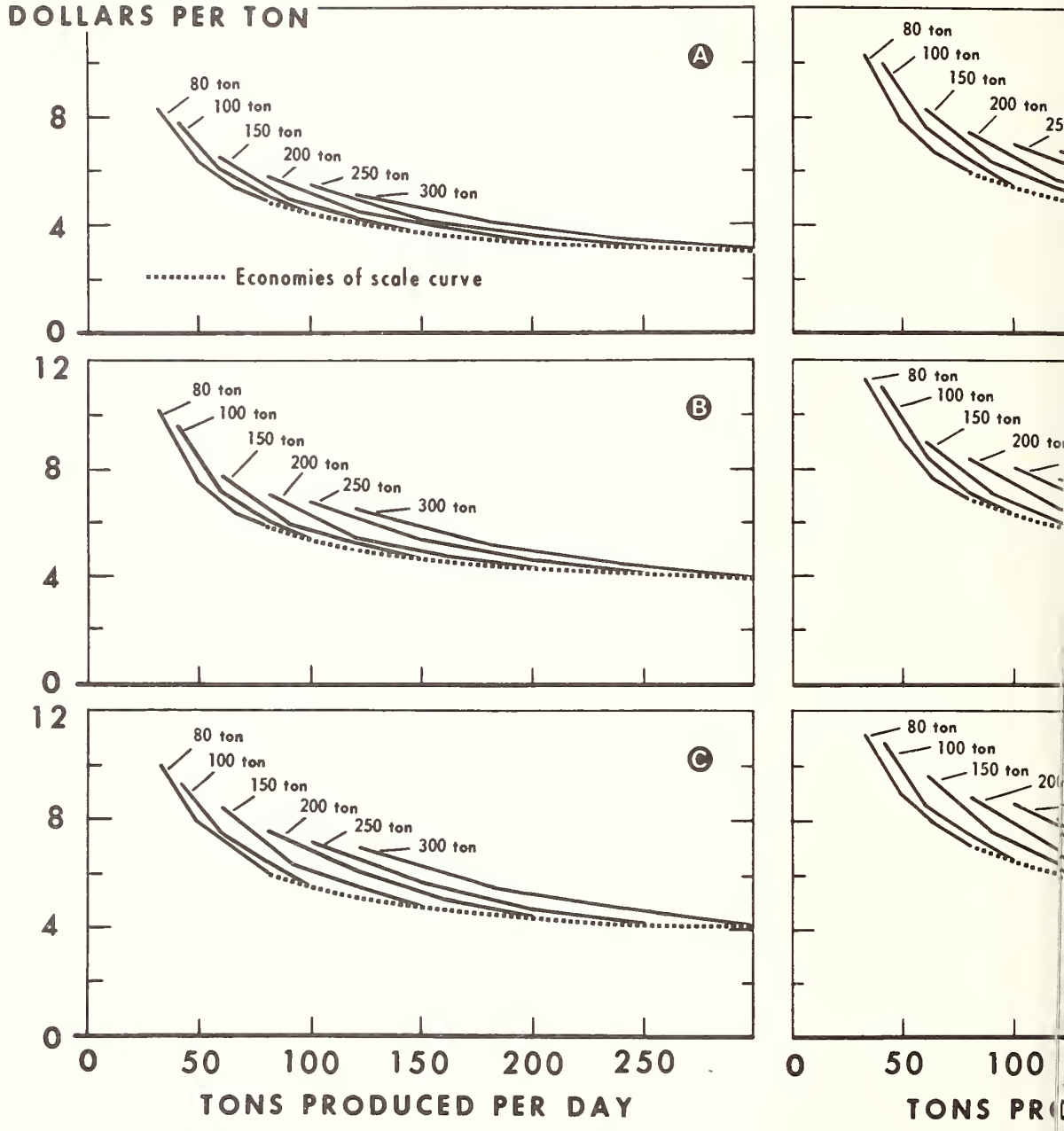
Table 15.--Electricity: Annual quantity used, annual cost, and cost per ton for model feed plants

Cost item by size of model	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
80 tons:										
Kilowatt-hours per year	Hours	281,100	282,150	282,900	469,900	470,950	471,700	375,500	376,550	377,300
Annual cost	Dollars	5,622	5,643	5,658	9,398	9,419	9,434	7,510	7,531	7,546
Cost per ton	Dollars	.27	.27	.27	.45	.45	.45	.36	.36	.36
100 tons:										
Kilowatt-hours per year	Hours	302,400	303,700	305,000	517,700	519,000	520,000	410,100	411,400	412,400
Annual cost	Dollars	6,048	6,074	6,100	10,354	10,380	10,400	8,202	8,228	8,248
Cost per ton	Dollars	.23	.23	.23	.40	.40	.40	.32	.32	.32
150 tons:										
Kilowatt-hours per year	Hours	345,800	347,650	349,000	675,500	676,750	678,750	493,500	495,350	496,600
Annual cost	Dollars	6,916	6,953	6,980	13,510	13,535	13,575	9,870	9,907	9,932
Cost per ton	Dollars	.18	.18	.18	.35	.35	.35	.25	.25	.25
200 tons:										
Kilowatt-hours per year	Hours	388,200	389,700	390,600	918,600	919,800	921,000	653,400	654,600	655,800
Annual cost	Dollars	7,764	7,794	7,812	18,372	18,396	18,420	13,068	13,092	13,116
Cost per ton	Dollars	.15	.15	.15	.35	.35	.35	.25	.25	.25
250 tons:										
Kilowatt-hours per year	Hours	467,300	468,600	470,400	1,135,500	1,136,800	1,138,600	802,400	803,700	805,500
Annual cost	Dollars	9,346	9,372	9,408	22,710	22,736	22,772	16,048	16,074	16,110
Cost per ton	Dollars	.14	.14	.14	.35	.35	.35	.25	.25	.25
300 tons:										
Kilowatt-hours per year	Hours	526,600	530,500	534,500	1,384,400	1,388,600	1,392,500	994,700	998,500	1,002,200
Annual cost	Dollars	10,532	10,610	10,690	27,688	27,772	27,850	19,894	19,894	20,044
Cost per ton	Dollars	.14	.14	.14	.35	.35	.35	.25	.25	.25

Table 16.--Operating costs for all models: Fixed, variable, and total, by operation

Cost item by size of model	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
80 tons:									
Fixed	2.26	2.48	2.41	2.63	2.80	2.75	2.55	2.76	2.69
Variable	2.57	3.28	3.63	3.34	4.03	4.38	3.32	4.01	4.38
Total	4.83	5.76	6.04	5.97	6.83	7.13	5.87	6.77	7.07
100 tons:									
Fixed	2.07	2.26	2.19	2.48	2.64	2.60	2.31	2.49	2.44
Variable	2.22	3.17	3.30	3.13	3.76	3.98	2.80	3.63	3.85
Total	4.29	5.43	5.49	5.61	6.40	6.58	5.11	6.12	6.29
150 tons:									
Fixed	1.72	1.86	1.83	2.02	2.17	2.12	1.88	2.04	1.98
Variable	1.95	2.70	2.96	2.56	3.33	3.57	2.41	3.19	3.41
Total	3.67	4.56	4.79	4.58	5.50	5.69	4.29	5.23	5.39
200 tons:									
Fixed	1.61	1.74	1.69	1.86	1.99	1.93	1.81	1.92	1.89
Variable	1.84	2.53	2.79	2.41	3.13	3.37	2.29	3.00	3.26
Total	3.45	4.27	4.48	4.27	5.12	5.30	4.10	4.92	5.15
250 tons:									
Fixed	1.51	1.69	1.64	1.78	1.93	1.87	1.74	1.89	1.81
Variable	1.67	2.37	2.62	2.25	2.92	3.18	2.13	2.79	3.03
Total	3.18	4.06	4.26	4.03	4.85	5.05	3.87	4.68	4.84
300 tons:									
Fixed	1.44	1.58	1.52	1.68	1.81	1.75	1.60	1.73	1.68
Variable	1.60	2.18	2.44	2.15	2.71	2.99	1.99	2.58	2.83
Total	3.04	3.76	3.96	3.83	4.52	4.74	3.59	4.31	4.51

FIGURE 2.-OPERATIONS OF BASI
AND ECONOMI



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MODELS: SHORTRUN COST CURVES
OF SCALE CURVE

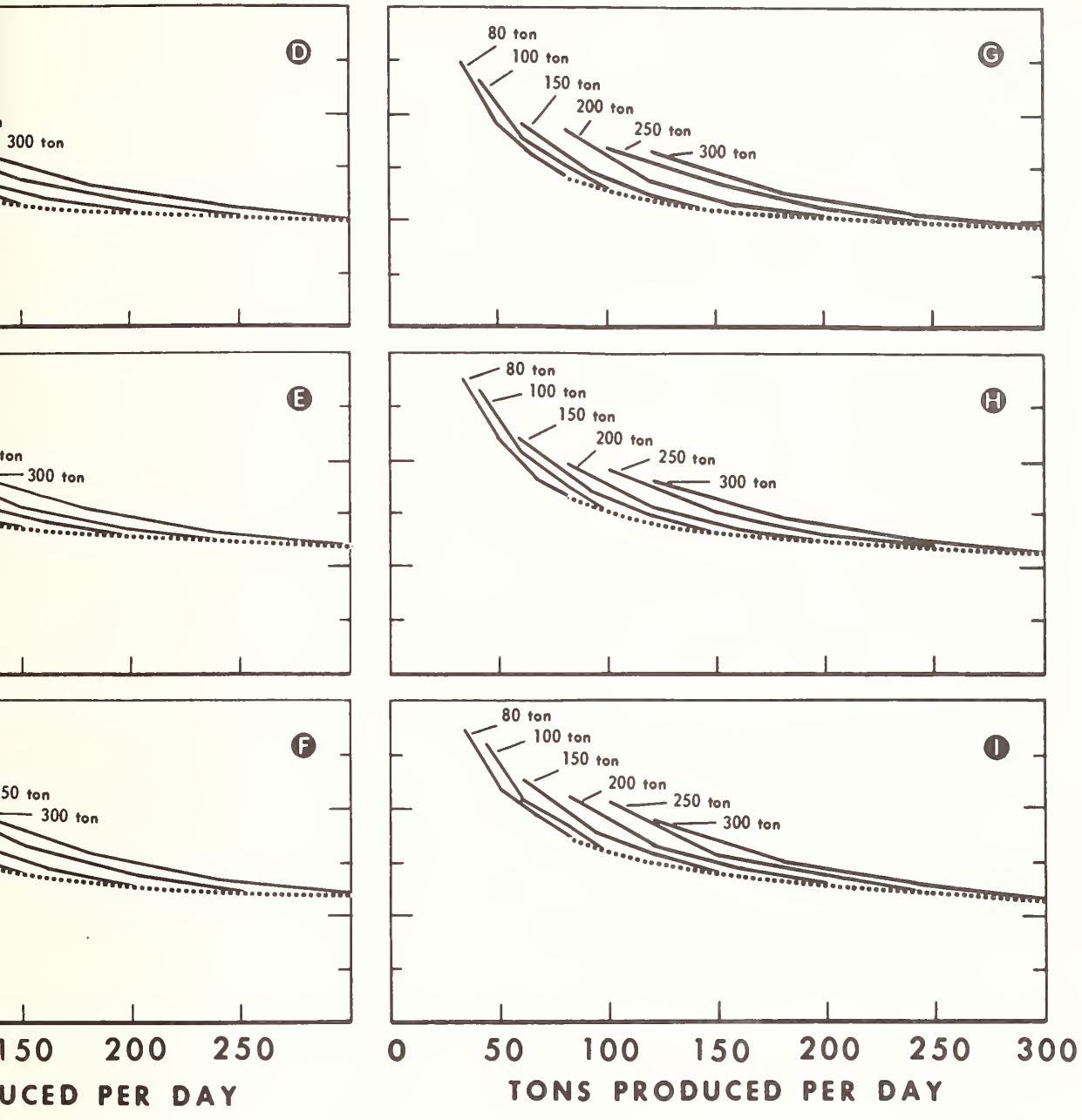

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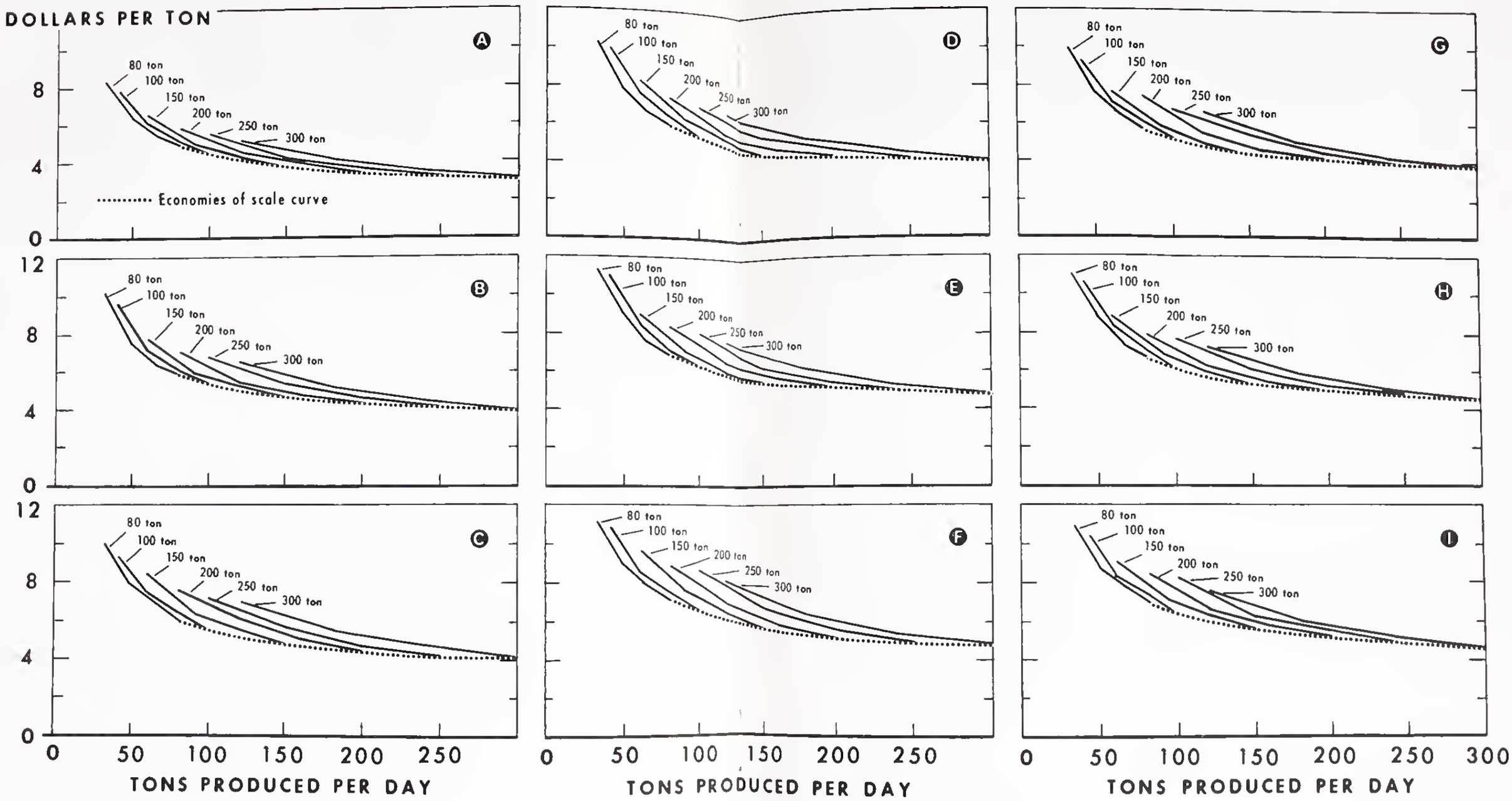
FIGURE 2.-OPERATIONS OF BASIC MODELS: SHORTRUN COST CURVES AND ECONOMIES OF SCALE CURVE



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constructed in this study assume output to be the optimum at 90 percent of plant rated capacity. Types of feeds produced have been limited to a semi-specialized operation. Under these conditions, labor allocation in all models approaches the minimum.

ECONOMIES OF SCALE

Two major cost relationships of concern to feed mill management are (1) the relationship of the size of mill (capacity) to the average per ton cost of manufacturing with fixed proportions of capacity utilized, and (2) the relationship of shortrun changes in the mixed feed output to the average cost with size of plant fixed. Figure 2 (center spread, pp 32-33) show the economies of scale curves and the shortrun average cost curves for the model mills when operated from 40 to 100 percent of capacity.

The economies of scale curves are the dotted lines in the figures. These curves show that as the size of the mill increases, the average cost per ton decreases when plants are operated at near capacity. Economies of scale are evident in most unit cost components within each model. There are greater economies in some cost components than in others as utilization of capacity increases--for example, the variable cost components tend to decrease at a slower rate than the fixed components.

Three major cost categories account for 85 percent of the economies. Labor is the most important and accounts for about 38 percent of the total economies of size. Ownership and administrative personnel cost are the second and third major sources of economies. Ownership accounts for about 36 percent and administrative accounts for about 11 percent of the total. Three other categories--utilities, equipment repair, and miscellaneous--account for the remaining 15 percent of the economies.

Examination of figure 2 indicates that further economies of size might exist for the larger operations. The economies of size curves have not become parallel with the output axis since each successive model has a lower average cost per ton when operated at its designed capacity. Further economies may be possible with equipment processing greater capacity and through other improved technologies. In practice, however, it appears likely that additional economies may well be offset by certain diseconomies, such as requiring additional formulas to satisfy additional markets, or an increase in procurement or distribution costs.

Shortrun Average Costs

Output of feed mills often drops over short periods because of seasonal fluctuations in livestock production. During these periods of reduced output, the capacities of the mills do not change. Therefore, with lower output, production costs per ton generally rise because fixed costs of mill ownership and management stay the same and plant efficiency in the use of labor is impaired. The effects of such shortrun changes in output on average cost per ton for each size of mill are shown in figure 2.

The production at which the shortrun average cost is the lowest in the level of output at which a given size plant is the most efficient At this point the value of inputs of resources per unit of output is lowest. Whatever the size of plant, the output with minimum average cost is the most efficient rate of production. The most efficient rate of output is not necessarily the level at which the plant is operated.

As plant size and output increase, the use of more efficient equipment and automation becomes more and more feasible. Automation in most cases increases the efficiency of labor and will result in a considerable reduction of per ton costs (fig. 2). As the size groups increase from 80 to 300 tons per 8-hour day, more automation is included in the model mill equipment. This enables a plant to operate at a lower level of capacity during the short run with lower variable costs. In the short run the plant must be able to cover variable costs but not fixed costs if it is to operate.

APPENDIX A

TOTAL PLANT COST

In estimating equipment and facility costs it is necessary to make certain assumptions which provide realistic estimates in most cases. Costs are representative costs for plants with the assigned capacities. But this does not mean that any of these models could not be built for less money or that the actual costs will not exceed these estimates.

As mentioned earlier in the report, there are many variables which affect costs of construction, equipment, and other items. All feed manufacturers do not have the same basic needs or requirements. Neither do they have the same amount of capital to invest. A mill as finally constructed will usually be a compromise between what the management believes is needed and what the capital available will provide.

Tables 17 through 22 show equipment costs for each major cost center and facility, and installation costs. Installation--mechanical, electrical, or plumbing--is a larger total cost item than is usually recognized. For each model in this study installation cost was an average percentage of equipment cost which equipment manufacturers and mill designers consider realistic. Actual installation cost may be higher or lower depending on local conditions.

The building cost index in table 23 illustrates the variations in construction costs during 1940-66. As the index shows, construction costs for steel have not increased as much as those for brick and concrete in most areas of the United States. This is one of the main reasons why many feed manufacturers are using steel when they build a new plant or add to an existing one. Also steel construction is more flexible than slip-form concrete construction; it usually does not require extensive pilings as concrete does, and it permits smaller facilities which are less expensive per cubic foot than concrete.

Table 17.--Equipment and facility costs: 80-ton model, 8 hours

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment:									
Receiving	23,570	23,570	23,570	23,570	23,570	23,570	23,570	23,570	23,570
Processing	5,700	5,700	5,700	5,700	5,700	5,700	5,700	5,700	5,700
Mixing	40,050	40,050	40,050	38,700	38,700	38,700	40,050	40,050	40,050
Pelleting	--	--	--	25,480	25,480	25,480	22,100	22,100	22,100
Packing	--	5,400	8,650	--	5,400	8,650	--	5,400	8,650
Warehousing (includes bulk load-out)	6,300	14,500	9,300	6,300	14,500	9,300	6,300	14,500	9,300
Miscellaneous	9,100	9,100	9,100	17,100	17,100	17,100	11,200	11,200	11,200
Total	84,720	98,320	96,370	116,850	130,450	128,500	108,920	122,520	120,570
Facilities:									
Mill building and workbins	108,230	114,410	114,410	116,390	119,570	119,570	120,570	121,890	121,890
Ingredient storage (outside)	8,920	8,920	8,920	8,920	8,920	8,920	8,920	8,920	8,920
Finished feed storage (bulk outside)	7,600	7,600	--	7,600	7,600	--	7,600	7,600	--
Warehouse	6,700	12,800	16,800	6,700	12,800	16,800	6,700	12,800	16,800
Boiler room	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600
Office	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Rail siding	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800
Total	147,850	160,130	156,530	156,010	165,290	161,690	160,190	167,610	164,010
Installation:									
Mechanical	42,360	51,100	48,200	58,400	67,150	64,250	54,460	63,190	60,290
Electrical	14,800	17,750	16,600	19,600	22,650	21,500	18,400	21,350	20,200
Plumbing	10,000	11,200	10,900	12,800	13,300	13,000	12,000	13,800	13,500
Total	67,160	80,050	75,700	90,800	103,100	98,750	84,860	98,340	93,990
Total cost	299,730	338,500	328,600	363,660	398,840	388,940	353,970	388,470	378,570

Table 18.--Equipment and facility costs: 100-ton model, 8 hours

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment:									
Receiving	27,375	27,375	27,375	27,375	27,375	27,375	27,375	27,375	27,375
Processing	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150
Mixing	48,895	48,895	48,895	47,550	47,550	47,550	48,895	48,895	48,895
Pelleting	--	--	--	42,900	42,900	42,900	22,100	22,100	22,100
Packing	--	7,600	10,200	--	7,600	10,200	--	7,600	10,200
Warehousing (includes bulk load-out)	7,500	15,000	10,100	7,500	15,000	10,100	7,500	15,000	10,100
Miscellaneous	10,200	10,200	10,200	18,100	18,100	18,100	12,200	12,200	12,200
Total	102,120	117,220	114,920	151,575	166,675	164,375	126,220	141,320	139,020
Facilities:									
Mill building and workbins	118,380	122,350	122,350	121,530	124,500	124,500	132,500	134,530	134,530
Ingredient storage (outside)	11,800	11,800	11,800	11,800	11,800	11,800	11,800	11,800	11,800
Finished feed storage (bulk outside)	9,250	9,000	--	9,250	9,000	--	9,250	9,000	--
Warehouse	8,400	16,000	21,000	8,400	16,000	21,000	8,400	16,000	21,000
Boiler room	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600
Office	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Rail siding	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800	4,800
Total	164,230	175,550	171,550	167,380	177,700	173,700	178,350	187,730	183,730
Installation:									
Mechanical	51,060	61,660	57,460	75,790	85,990	82,190	63,110	73,310	69,510
Electrical	15,500	18,400	17,500	22,800	25,700	24,800	19,000	21,900	21,000
Plumbing	10,500	11,600	11,500	15,500	17,400	16,900	12,900	15,000	14,500
Total	77,060	91,660	86,460	114,090	129,090	123,890	95,010	110,210	105,010
Total cost	343,410	384,430	372,930	433,045	473,465	461,965	399,580	439,260	427,760

Table 19.--Equipment and facility costs: 150-ton model, 8 hours

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment:									
Receiving	34,775	34,775	34,775	34,775	34,775	34,775	34,775	34,775	34,775
Processing	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200	11,200
Mixing	57,200	57,200	57,200	53,200	53,200	53,200	57,200	57,200	57,200
Pelleting	--	--	--	52,800	52,800	52,800	25,478	25,478	25,478
Packing	--	8,500	12,300	--	8,500	12,300	--	8,500	12,300
Warehousing (includes bulk load-out)	8,000	16,500	10,000	8,000	16,500	10,000	8,000	16,500	10,000
Miscellaneous	11,000	11,000	11,000	19,600	19,600	19,600	13,600	13,600	13,600
Total	122,175	139,175	136,475	179,575	196,575	193,875	150,253	167,253	164,553
Facilities:									
Mill building and workbins	131,530	139,530	139,530	135,260	141,260	141,260	143,260	149,260	149,260
Ingredient storage (outside)	20,200	20,200	20,200	20,200	20,200	20,200	20,200	20,200	20,200
Finished feed storage (bulk outside)	12,400	11,000	--	12,400	11,000	--	12,400	11,000	--
Warehouse	12,600	24,500	31,500	12,600	24,500	31,500	12,600	24,500	31,500
Boiler room	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200
Office	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Rail siding	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200
Total	198,130	216,630	212,630	201,860	218,260	214,360	209,860	226,360	222,360
Installation:									
Mechanical	61,090	72,140	68,240	89,790	100,840	96,940	75,130	86,180	82,280
Electrical	18,500	21,500	20,700	27,200	80,000	29,200	22,800	25,700	24,900
Plumbing	12,500	15,500	14,900	18,200	20,200	19,600	15,300	17,400	16,800
Total	92,090	109,140	103,840	135,190	151,040	145,740	113,230	129,280	123,980
Total cost	412,395	464,945	452,945	516,625	565,975	553,975	473,343	522,893	510,893

Table 20.--Equipment and facility costs: 200-ton model, 8 hours

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment:									
Receiving	53,180	53,180	53,180	53,180	53,180	53,180	53,180	53,180	53,180
Processing	16,700	16,700	16,700	16,700	16,700	16,700	16,700	16,700	16,700
Mixing	68,800	68,800	68,800	64,800	64,800	64,800	68,800	68,800	68,800
Pelleting	--	--	--	58,950	58,950	58,950	42,900	42,900	42,900
Packing	--	10,400	14,050	--	10,400	14,050	--	10,400	14,050
Warehousing (includes bulk load-out)	15,500	19,500	10,000	15,500	19,500	10,000	15,500	19,500	10,000
Miscellaneous	18,100	18,100	18,100	28,100	28,100	28,100	21,100	21,100	21,100
Total	172,280	186,680	180,830	237,230	251,630	245,780	218,180	232,580	226,730
Facilities:									
Mill building and workbins	147,740	162,580	161,580	150,940	153,890	153,890	153,890	167,190	167,190
Ingredient storage (outside)	25,100	25,100	25,100	25,100	25,100	25,100	25,100	25,100	25,100
Finished feed storage (bulk outside)	16,500	12,400	--	16,500	12,400	--	16,500	12,400	--
Warehouse	16,800	33,600	42,000	16,800	33,600	42,000	16,800	33,600	42,000
Boiler room	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200
Office	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Rail siding	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200
Total	227,540	255,080	250,080	230,740	246,390	242,390	233,690	259,690	255,690
Installation:									
Mechanical	86,140	97,300	90,415	118,615	129,775	122,890	109,090	120,250	113,365
Electrical	26,000	28,665	27,300	35,800	38,365	37,000	32,900	35,665	34,300
Plumbing	17,500	19,100	18,200	23,900	25,700	24,800	21,900	23,800	22,900
Total	129,640	145,065	135,915	178,315	193,840	184,690	163,890	179,715	170,565
Total cost	529,460	586,825	566,825	646,285	691,860	672,860	615,760	671,985	652,985

Table 21.--Equipment and facility costs: 250-ton model, 8 hours

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment:									
Receiving	55,600	55,600	55,600	55,600	55,600	55,600	55,600	55,600	55,600
Processing	22,100	22,100	22,100	22,100	22,100	22,100	22,100	22,100	22,100
Mixing	77,800	77,800	77,800	73,400	73,400	73,400	77,800	77,800	77,800
Pelleting	--	--	--	71,300	71,300	71,300	52,800	52,800	52,800
Packing	--	13,200	21,150	--	13,200	21,150	--	13,200	21,150
Warehousing (includes bulk load-out)	15,500	26,500	15,500	15,500	26,500	15,500	15,500	26,500	15,500
Miscellaneous	19,100	19,100	19,100	31,100	31,100	31,100	24,100	24,100	24,100
Total	190,100	214,300	211,250	269,000	293,200	290,150	247,900	272,100	269,050
Facilities:									
Mill building and workbins	180,380	192,280	192,280	180,260	190,160	190,160	195,160	204,510	204,510
Ingredient storage (outside)	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700
Finished feed storage (bulk outside)	27,900	22,500	--	27,900	22,500	--	27,900	22,500	--
Warehouse	21,000	40,500	52,500	21,000	40,500	52,500	21,000	40,500	52,500
Boiler room	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Office	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Rail siding	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Total	278,180	304,180	293,680	278,060	302,060	291,560	292,960	316,410	305,910
Installation:									
Mechanical	95,050	110,175	105,375	134,500	149,625	144,825	123,950	139,075	134,275
Electrical	28,100	33,200	31,700	40,500	45,200	43,700	37,600	42,000	40,500
Plumbing	19,200	22,700	21,200	27,000	30,500	29,000	24,900	28,500	27,000
Total	142,350	166,075	158,275	202,000	225,325	217,525	186,450	209,575	201,775
Total cost	610,630	684,555	663,205	749,060	820,585	799,235	727,310	798,085	776,735

Table 22.--Equipment and facility costs: 300-ton model, 8 hours

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment:									
Receiving	57,300	57,300	57,300	57,300	57,300	57,300	57,300	57,300	57,300
Processing	27,700	27,700	27,700	27,700	27,700	27,700	27,700	27,700	27,700
Mixing	80,700	80,700	80,700	76,300	76,300	76,300	80,700	80,700	80,700
Pelleting	--	--	--	82,400	82,400	82,400	52,800	52,800	52,800
Packing	--	17,050	23,450	--	17,050	23,450	--	17,050	23,450
Warehousing (includes bulk load-out)	15,500	23,900	15,000	15,500	23,900	15,000	15,000	23,900	15,000
Miscellaneous	20,000	20,000	20,000	35,100	35,100	35,100	27,100	27,100	27,100
Total	201,200	226,650	224,150	294,300	319,750	317,250	260,600	286,550	284,050
Facilities:									
Mill building and workbins	200,490	214,340	214,340	200,950	207,780	207,780	207,780	213,950	213,950
Ingredient storage (outside)	24,800	24,800	24,800	24,800	24,800	24,800	24,800	24,800	24,800
Finished feed storage (bulk outside)	34,900	26,300	--	34,900	26,300	--	34,900	26,300	--
Warehouse	25,200	46,500	63,000	25,200	46,500	63,000	25,200	46,500	63,000
Boiler room	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Office	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Rail siding	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Total	313,590	340,140	330,340	314,050	333,580	323,780	320,880	339,750	329,950
Installation:									
Mechanical	100,600	114,575	112,075	147,150	161,125	158,625	130,550	144,525	142,025
Electrical	30,500	34,400	33,900	44,400	48,400	47,900	39,500	43,400	42,900
Plumbing	20,500	23,000	22,600	29,600	32,300	31,900	26,300	29,000	28,600
Total	151,600	171,975	168,575	221,150	241,825	238,425	196,350	216,925	213,525
Total cost	666,390	738,765	723,065	829,500	895,155	879,455	777,830	843,225	827,525

Table 23.--Building costs index: Commercial and factory buildings, selected cities
[1926-29 = 100]

City	1940		1950		1962		1964		1966	
	Steel constr.	Brick concrete constr.	Steel constr.	Brick concrete constr.	Steel constr.	Brick concrete constr.	Steel constr.	Brick concrete constr.	Steel constr.	Brick concrete constr.
Albuquerque	123	109	223	219	293	311	306	335	324	360
Atlanta	100	98	183	184	269	293	281	312	299	332
Buffalo	104	109	199	220	313	368	322	381	343	411
Chicago	118	128	201	223	307	352	323	379	346	408
Cincinnati	112	119	199	219	302	346	314	363	333	384
Dallas	113	101	206	208	278	291	285	300	298	321
Denver	120	120	212	221	301	326	312	343	329	366
Des Moines	117	118	206	220	305	343	316	362	331	382
Indianapolis	108	115	198	213	295	327	306	344	326	368
Jacksonville	100	90	184	184	259	255	266	266	281	285
Kansas City, Mo	117	122	204	218	303	330	313	351	334	376
Los Angeles	109	104	206	219	337	365	350	386	373	417
Memphis	104	100	188	188	274	286	281	300	298	317
Minneapolis-St. Paul	114	117	198	211	303	347	315	366	337	387
New Orleans	105	99	194	195	278	290	286	305	304	327
Omaha	105	103	197	199	292	319	303	336	315	356
Portland, Oreg	110	115	213	228	320	361	330	375	357	414
Richmond	106	92	183	187	264	267	269	277	280	290
Seattle	113	125	214	234	326	369	338	390	362	421
U.S. average	111	114	203	219	306	344	318	365	342	395

Source: Boeckh's Manual of Appraisals, Building Cost Monthly Index Reports for the periods shown.

To insure construction of a compact, efficient feed mill, management usually engages an engineering firm to design it. A typical contract which might be used by a feed mill designer and a feed manufacturer follows. Many feed manufacturers have attempted to sidestep designing expense, but soon realize that it is as important as the mill foundation itself.

SAMPLE ENGINEERING AND EQUIPMENT CONTRACT

BETWEEN: _____

_____

_____

AND: FEED MILL ENGINEERS, INC.
CONCENTRATE
KANSAS

It is mutually agreed between the above parties as follows:

I. FEED MILL ENGINEERS, INC., CONCENTRATE, KANSAS (hereinafter called FEED MILLS, INC.) will provide engineering as described hereinafter and furnish equipment, in accordance with the terms of this Agreement, for a feed mill generally as shown on (drawings, specifications, etc.) _____ to be located at _____ _____(hereinafter called _____ _____) and said drawings are attached to and are a part of this Contract.

II. ENGINEERING

(A) With the exceptions of those phases itemized in II (B), the engineering will consist of plans and specifications for a complete feed mill. The mill structure will be designed in reinforced concrete where applicable with all other materials of construction to be selected by_____. Plans and specifications will be prepared in sufficient detail to permit competitive bidding in each of the various phases by contractors

representing their respective trades or competitive bidding on the overall project by general contractors.

(B) Payment of Engineering

The engineering charges to provide the above listed engineering will be invoiced separately to _____ in accordance with the following rates and terms:

(1) Engineering time at _____ Dollars ( ) per man hour and Drafting time at _____ Dollars ( ) per man hour for Engineering and Drafting work performed during normal working hours. Overtime will not be worked unless requested by _____ _____, at which time rates will be negotiated.

(2) Living and travel expense of Feed Mills, Inc. employees at Feed Mills, Inc.'s out-of-pocket cost except, when Feed Mills, Inc. vehicles are used, the rate shall be at ___ Cents ( ) per mile.

(3) All other engineering expense at Feed Mills, Inc.'s cost plus _____ Per Cent ( ). This would include, but is not limited to, special outside engineering consultation or special materials required for completing the engineering. The engineering charge will be billed monthly at the above specified rates.

(C) Engineering Rebate

The engineering charge accrued under Paragraph II (B) will be credited to _____ at the rate of _____ Per Cent ( ) of the value of Feed Mills, Inc. manufactured equipment purchased for this project, up to a maximum credit of _____ Per Cent ( ) of such engineering charge.

III. FURNISHING OF EQUIPMENT

_____ will purchase all equipment (except that manufactured by others as provided in this Paragraph III (B) necessary for this mill from Feed Mills, Inc., F. O. B. Point of Manufacture in accordance with the provisions in this Paragraph III. Major items of equipment are listed on the attached Exhibit A which is incorporated into this Contract. Additional equipment may be required when the final engineering is completed and if such additional equipment is needed, it is understood that such equipment will also be purchased from Feed Mills, Inc. in accordance with the provisions herein:

(A) Feed Mills, Inc. manufactured equipment

On the attached Exhibit A, certain items of equipment are indicated to be manufactured by Feed Mills, Inc. These items will be priced and invoiced in accordance with Feed Mills, Inc.'s user prices in effect at the time exact specifications are determined and approval is given by _____ for manufacture. The price of this equipment will be used in computing the amount of engineering credit provided in Paragraph II (D) above.

(B) Equipment manufactured by others

All equipment manufactured by others shall be purchased from Feed Mills, Inc. at Feed Mills, Inc.'s O.E.M. cost plus _____ Per Cent ( ) or by _____ directly on the basis of which party can supply the item at least cost to _____.

IV. CODES, PERMITS AND FEES

All engineering work will be performed in accordance with all State and Local Codes which might be applicable. Feed Mills, Inc. will provide in all specifications that all contractors shall obtain all necessary permits for construction and installation.

V. CANCELLATION

If at any time _____ decides not to build this mill, this Contract may be cancelled provided, however, that _____ shall pay Feed Mills, Inc. all charges accrued up to and including the date of cancellation in accordance with the rate and change schedules listed in this Contract plus any cancellation charges resulting from machinery and equipment manufactured or in the process of being manufactured.

IN WITNESS WHEREOF, the parties hereto have executed and delivered this Agreement this _____ Day of _____, 196 .

FEED MILL, ENGINEERS, INC.

WITNESS: By _____

_____ Title _____

_____

WITNESS: By _____

_____ Title _____

EXHIBIT A

MAJOR ITEMS OF EQUIPMENT

ITEM	DESCRIPTION	MANUFACTURED BY
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APPENDIX B

LABOR INPUTS AND COSTS

Labor inputs as used in this study refer to all plant labor, including production and maintenance workers as well as supervisors. Work includes the manufacturing process, maintenance and repair work, housekeeping chores, and supervision of all work in the plant.

Many feed manufacturing facilities today are being renovated, or even closed because costs are too high or the location is not suitable for the highly competitive conditions. In new or renovated plants, labor is being largely replaced by machines, although the automated specialized mills being built today require a few key personnel.

The feed manufacturing industry, like many agriculture-related industries, has difficulty in obtaining personnel. This has forced many manufacturers to automate sooner than they would have otherwise.

Equipment used in the models in this report ranges from that used by manual or semiautomatic mixing to fully automatic mixing. Mixing probably reflects automation more than other cost centers in the models. However, remote control of equipment from a central panel--a main feature of full automation--helps keep operating costs low.

Estimated labor requirements for all operations of the six basic models are shown in tables 24-29. Labor requirements for each center are measured in units of 1 hour. In most feed plants, workers are assumed to be full-time employees who would remain on the job during slack periods to do miscellaneous housekeeping and maintenance chores. Table 30 shows man-hours required for four levels of output in each model size.

Tables 24-29 provide details on annual and per ton cost as well as labor use for each cost center in the model mills. Labor costs for each operation are estimated by the actual tonnage handled in each cost center. In most cases the total mill tonnage is used. The exceptions are pelleting operations G, H, and I; and packing operations B, E, and H, whose costs are based on handling only 50 percent of the mill's capacity.

Table 24.--80-ton model: Man-hours per day, annual labor cost, and cost per ton of mixed feed

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
Receiving										
Labor per day	Man-hours	7	7	7	7	7	7	7	7	7
Annual cost	Dollars	4,641	4,641	4,641	4,641	4,641	4,641	4,641	4,641	4,641
Cost per ton	Dollars	.22	.22	.22	.22	.22	.22	.22	.22	.22
Processing										
Labor per day	Man-hours	2	2	2	2	2	2	2	2	2
Annual cost	Dollars	1,326	1,326	1,326	1,326	1,326	1,326	1,326	1,326	1,326
Cost per ton	Dollars	.06	.06	.06	.06	.06	.06	.06	.06	.06
Mixing										
Labor per day	Man-hours	8	8	8	8	8	8	8	8	8
Annual cost	Dollars	5,304	5,304	5,304	5,304	5,304	5,304	5,304	5,304	5,304
Cost per ton	Dollars	.25	.25	.25	.25	.25	.25	.25	.25	.25
Pelleting										
Labor per day	Man-hours	--	--	--	7	7	7	5	5	5
Annual cost	Dollars	--	--	--	4,641	4,641	4,641	3,315	3,315	3,315
Cost per ton	Dollars	--	--	--	.22	.22	.22	.32	.32	.32
Packing										
Labor per day	Man-hours	--	4	8	--	4	8	--	4	8
Annual cost	Dollars	--	2,652	5,304	--	2,652	5,304	--	2,652	5,304
Cost per ton	Dollars	--	.26	.25	--	.26	.25	--	.26	.25
Warehousing										
Labor per day	Man-hours	4	16	28	4	15	27	4	17	28
Annual cost	Dollars	2,652	10,608	18,564	2,652	9,945	17,901	2,652	11,271	18,564
Cost per ton	Dollars	.13	.51	.89	.13	.48	.86	.13	.54	.89
Miscellaneous										
Labor per day	Man-hours	3	2	2	3	3	3	3	2	3
Annual cost	Dollars	1,989	1,326	1,326	1,989	1,989	1,989	1,989	1,326	1,989
Cost per ton	Dollars	.10	.06	.06	.10	.10	.10	.10	.06	.10
Maintenance										
Labor per day	Man-hours	8	8	8	8	9	9	9	9	9
Annual cost	Dollars	5,928	5,928	5,928	5,928	6,669	6,669	6,669	6,669	6,669
Cost per ton	Dollars	.28	.28	.28	.28	.32	.32	.32	.32	.32
Total										
Labor per day	Man-hours	32	47	63	39	55	71	38	54	70
Annual cost	Dollars	21,840	31,785	42,393	26,481	37,167	47,775	25,896	36,504	47,112
Cost per ton	Dollars	1.04	1.64	2.01	1.26	1.91	2.28	1.40	2.03	2.41
Supervisor										
Labor per day	Man-hours	8	9	9	9	9	9	10	10	10
Annual cost	Dollars	6,448	7,254	7,254	7,254	7,254	7,254	8,060	8,060	8,060
Cost per ton	Dollars	.31	.35	.35	.35	.35	.35	.39	.39	.39

Table 25.--100-ton model: Man-hours per day, annual labor cost, and cost per ton of mixed feed

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
Receiving										
Labor per day	Man-hours	8	8	8	8	8	8	8	8	8
Annual cost	Dollars	5,304	5,304	5,304	5,304	5,304	5,304	5,304	5,304	5,304
Cost per ton	Dollars	.20	.20	.20	.20	.20	.20	.20	.20	.20
Processing										
Labor per day	Man-hours	2	2	2	2	2	2	2	2	2
Annual cost	Dollars	1,326	1,326	1,326	1,326	1,326	1,326	1,326	1,326	1,326
Cost per ton	Dollars	.05	.05	.05	.05	.05	.05	.05	.05	.05
Mixing										
Labor per day	Man-hours	10	10	10	10	10	10	10	10	10
Annual cost	Dollars	6,630	6,630	6,630	6,630	6,630	6,630	6,630	6,630	6,630
Cost per ton	Dollars	.25	.25	.25	.25	.25	.25	.25	.25	.25
Pelleting										
Labor per day	Man-hours	--	--	--	8	8	8	4	4	4
Annual cost	Dollars	--	--	--	5,304	5,304	5,304	2,652	2,652	2,652
Cost per ton	Dollars	--	--	--	.20	.20	.20	.20	.20	.20
Packing										
Labor per day	Man-hours	--	6	9	--	6	9	--	6	10
Annual cost	Dollars	--	3,978	5,967	--	3,978	5,967	--	3,978	6,630
Cost per ton	Dollars	--	.31	.23	--	.31	.23	--	.31	.25
Warehousing										
Labor per day	Man-hours	3	17	31	4	16	30	4	19	32
Annual cost	Dollars	1,989	11,271	20,553	2,652	10,608	19,890	2,652	12,597	21,216
Cost per ton	Dollars	.08	.43	.79	.10	.41	.76	.10	.48	.81
Miscellaneous										
Labor per day	Man-hours	1	2	2	5	3	2	1	4	3
Annual cost	Dollars	663	1,326	1,326	3,315	1,989	1,326	663	2,652	1,989
Cost per ton	Dollars	.02	.05	.05	.13	.08	.05	.02	.10	.08
Maintenance										
Labor per day	Man-hours	8	9	8	9	9	9	9	9	9
Annual cost	Dollars	5,928	6,669	5,928	6,669	6,669	6,669	6,669	6,669	6,669
Cost per ton	Dollars	.23	.26	.23	.26	.26	.26	.26	.26	.26
Total										
Labor per day	Man-hours	32	54	70	46	62	78	38	62	78
Annual cost	Dollars	21,840	36,504	47,034	31,200	41,808	52,416	25,896	41,808	52,416
Cost per ton	Dollars	.83	1.55	1.80	1.19	1.76	2.00	1.08	1.85	2.10
Supervisor										
Labor per day	Man-hours	8	10	10	10	10	10	10	10	10
Annual cost	Dollars	6,448	8,060	8,060	8,060	8,060	8,060	8,060	8,060	8,060
Cost per ton	Dollars	.25	.31	.31	.31	.31	.31	.31	.31	.31

Table 26.--150-ton model: Man-hours per day, annual labor cost, and cost per ton of mixed feed

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
Receiving										
Labor per day	Man-hours	12	12	12	12	12	12	12	12	12
Annual cost	Dollars	7,956	7,956	7,956	7,956	7,956	7,956	7,956	7,956	7,956
Cost per ton	Dollars	.20	.20	.20	.20	.20	.20	.20	.20	.20
Processing										
Labor per day	Man-hours	2	2	2	2	2	2	2	2	2
Annual cost	Dollars	1,326	1,326	1,326	1,326	1,326	1,326	1,326	1,326	1,326
Cost per ton	Dollars	.03	.03	.03	.03	.03	.03	.03	.03	.03
Mixing										
Labor per day	Man-hours	14	14	14	14	14	14	14	14	14
Annual cost	Dollars	9,282	9,282	9,282	9,282	9,282	9,282	9,282	9,282	9,282
Cost per ton	Dollars	.24	.24	.24	.24	.24	.24	.24	.24	.24
Pelleting										
Labor per day	Man-hours	--	--	--	8	8	8	6	6	6
Annual cost	Dollars	--	--	--	5,304	5,304	5,304	3,978	3,978	3,978
Cost per ton	Dollars	--	--	--	.14	.14	.14	.20	.20	.20
Packing										
Labor per day	Man-hours	--	9	14	--	9	14	--	9	14
Annual cost	Dollars	--	5,967	9,282	--	5,967	9,282	--	5,967	9,282
Cost per ton	Dollars	--	.31	.24	--	.31	.24	--	.31	.24
Warehousing										
Labor per day	Man-hours	5	25	43	4	24	43	5	26	45
Annual cost	Dollars	3,315	16,575	28,509	2,652	15,912	28,509	3,315	17,238	29,835
Cost per ton	Dollars	.08	.42	.73	.07	.41	.73	.08	.44	.76
Miscellaneous										
Labor per day	Man-hours	3	2	3	2	3	3	3	3	3
Annual cost	Dollars	1,989	1,326	1,989	1,326	1,989	1,989	1,989	1,989	1,989
Cost per ton	Dollars	.05	.03	.05	.03	.05	.05	.05	.05	.05
Maintenance										
Labor per day	Man-hours	10	12	12	11	12	12	11	12	12
Annual cost	Dollars	7,410	8,892	8,892	8,151	8,892	8,892	8,151	8,892	8,892
Cost per ton	Dollars	.19	.23	.23	.21	.23	.23	.21	.23	.23
Total										
Labor per day	Man-hours	46	76	100	53	84	108	53	84	108
Annual cost	Dollars	31,278	51,324	67,236	35,997	56,628	72,540	35,997	56,628	72,540
Cost per ton	Dollars	.79	1.46	1.72	.92	1.61	1.86	1.01	1.70	1.95
Supervisor										
Labor per day	Man-hours	10	12	12	11	12	12	11	12	12
Annual cost	Dollars	8,060	9,672	9,672	8,866	9,672	9,672	8,866	9,672	9,672
Cost per ton	Dollars	.21	.25	.25	.23	.25	.25	.23	.25	.25

Table 27.--200-ton model: Man-hours per day, annual labor cost, and cost per ton of mixed feed

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
Receiving										
Labor per day	Man-hours	14	14	14	14	14	14	14	14	14
Annual cost	Dollars	9,282	9,282	9,282	9,282	9,282	9,282	9,282	9,282	9,282
Cost per ton	Dollars	.18	.18	.18	.18	.18	.18	.18	.18	.18
Processing										
Labor per day	Man-hours	3	3	3	3	3	3	3	3	3
Annual cost	Dollars	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989
Cost per ton	Dollars	.04	.04	.04	.04	.04	.04	.04	.04	.04
Mixing										
Labor per day	Man-hours	16	16	16	16	16	16	16	16	16
Annual cost	Dollars	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608
Cost per ton	Dollars	.20	.20	.20	.20	.20	.20	.20	.20	.02
Pelleting										
Labor per day	Man-hours	--	--	--	9	9	9	7	7	7
Annual cost	Dollars	--	--	--	5,967	5,967	5,967	4,641	4,641	4,641
Cost per ton	Dollars	--	--	--	.11	.11	.11	.18	.18	.18
Packing										
Labor per day	Man-hours	--	11	19	--	10	18	--	11	19
Annual cost	Dollars	--	7,293	12,597	--	6,630	11,934	--	7,293	12,597
Cost per ton	Dollars	--	.28	.24	--	.26	.23	--	.28	.24
Warehousing										
Labor per day	Man-hours	5	33	57	5	31	56	5	33	57
Annual cost	Dollars	3,315	21,879	37,791	3,315	20,553	37,128	3,315	21,879	37,791
Cost per ton	Dollars	.06	.42	.73	.06	.40	.71	.06	.42	.73
Miscellaneous										
Labor per day	Man-hours	5	5	5	3	5	4	5	4	4
Annual cost	Dollars	3,315	3,315	3,315	1,989	3,315	2,652	3,315	2,652	2,652
Cost per ton	Dollars	.06	.06	.06	.04	.06	.05	.06	.05	.05
Maintenance										
Labor per day	Man-hours	14	15	15	15	16	16	15	16	16
Annual cost	Dollars	10,374	11,115	11,115	11,115	11,856	11,856	11,115	11,856	11,856
Cost per ton	Dollars	.20	.21	.21	.21	.23	.23	.21	.23	.23
Total										
Labor per day	Man-hours	57	97	129	65	104	136	65	104	136
Annual cost	Dollars	38,883	65,481	86,697	44,265	70,200	91,416	44,265	70,200	91,416
Cost per ton	Dollars	.74	1.39	1.66	.84	1.48	1.75	.93	1.58	1.85
Supervisor										
Labor per day	Man-hours	15	15	15	15	16	16	15	16	16
Annual cost	Dollars	12,090	12,090	12,090	12,090	12,896	12,896	12,090	12,896	12,896
Cost per ton	Dollars	.23	.23	.23	.23	.25	.25	.23	.25	.25

Table 28.--250-ton model: Man-hours per day, annual labor cost, and cost per ton of mixed feed

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
Receiving										
Labor per day	Man-hours	14	14	14	14	14	14	14	14	14
Annual cost	Dollars	9,282	9,282	9,282	9,282	9,282	9,282	9,282	9,282	9,282
Cost per ton	Dollars	.14	.14	.14	.14	.14	.14	.14	.14	.14
Processing										
Labor per day	Man-hours	3	3	3	3	3	3	3	3	3
Annual cost	Dollars	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989
Cost per ton	Dollars	.03	.03	.03	.03	.03	.03	.03	.03	.03
Mixing										
Labor per day	Man-hours	16	16	16	16	16	16	16	16	16
Annual cost	Dollars	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608
Cost per ton	Dollars	.16	.16	.16	.16	.16	.16	.16	.16	.16
Pelleting										
Labor per day	Man-hours	--	--	--	10	10	10	8	8	8
Annual cost	Dollars	--	--	--	6,630	6,630	6,630	5,304	5,304	5,304
Cost per ton	Dollars	--	--	--	.10	.10	.10	.16	.16	.16
Packing										
Labor per day	Man-hours	--	13	23	--	12	22	--	13	23
Annual cost	Dollars	--	8,619	15,249	--	7,956	14,586	--	8,619	15,249
Cost per ton	Dollars	--	.26	.23	--	.24	.22	--	.26	.23
Warehousing										
Labor per day	Man-hours	6	37	67	5	36	66	5	37	67
Annual cost	Dollars	3,978	24,531	44,421	3,315	23,868	43,758	3,315	24,531	44,421
Cost per ton	Dollars	.06	.38	.68	.05	.37	.67	.05	.38	.68
Miscellaneous										
Labor per day	Man-hours	5	5	5	4	5	5	2	5	5
Annual cost	Dollars	3,315	3,315	3,315	2,652	3,315	3,315	1,326	3,315	3,315
Cost per ton	Dollars	.05	.05	.05	.04	.05	.05	.02	.05	.05
Maintenance										
Labor per day	Man-hours	18	20	20	18	20	20	20	20	20
Annual cost	Dollars	13,338	14,820	14,820	13,338	14,820	14,820	14,820	14,820	14,820
Cost per ton	Dollars	.21	.23	.23	.21	.23	.23	.23	.23	.23
Total										
Labor per day	Man-hours	62	108	148	70	116	156	68	116	156
Annual cost	Dollars	42,510	73,164	99,684	47,814	78,468	104,988	46,644	78,468	104,988
Cost per ton	Dollars	.65	1.25	1.52	.73	1.32	1.60	.79	1.41	1.68
Supervisor										
Labor per day	Man-hours	18	20	20	18	20	20	20	20	20
Annual cost	Dollars	14,508	16,120	16,120	14,508	16,120	16,120	16,120	16,120	16,120
Cost per ton	Dollars	.22	.25	.25	.22	.25	.25	.25	.25	.25

Table 29.--300-ton model: Man-hours per day, annual labor cost, and cost per ton of mixed feed

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
Receiving										
Labor per day	Man-hours	16	16	16	16	16	16	16	16	16
Annual cost	Dollars	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608
Cost per ton	Dollars	.14	.14	.14	.14	.14	.14	.14	.14	.14
Processing										
Labor per day	Man-hours	3	3	3	3	3	3	3	3	3
Annual cost	Dollars	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989
Cost per ton	Dollars	.02	.02	.02	.02	.02	.02	.02	.02	.02
Mixing										
Labor per day	Man-hours	16	16	16	16	16	16	16	16	16
Annual cost	Dollars	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608	10,608
Cost per ton	Dollars	.14	.14	.14	.14	.14	.14	.14	.14	.14
Pelleting										
Labor per day	Man-hours	--	--	--	11	11	11	8	8	8
Annual cost	Dollars	--	--	--	7,293	7,293	7,293	5,304	5,304	5,304
Cost per ton	Dollars	--	--	--	.09	.09	.09	.14	.14	.14
Packing										
Labor per day	Man-hours	--	14	26	--	13	25	--	14	26
Annual cost	Dollars	--	9,282	17,238	--	8,619	16,575	--	9,282	17,238
Cost per ton	Dollars	--	.24	.22	--	.22	.21	--	.24	.22
Warehousing										
Labor per day	Man-hours	8	38	75	6	37	73	6	38	75
Annual cost	Dollars	5,304	25,194	49,725	3,978	24,531	48,399	3,978	25,194	49,725
Cost per ton	Dollars	.07	.32	.64	.05	.31	.62	.05	.32	.64
Miscellaneous										
Labor per day	Man-hours	5	5	4	4	4	4	3	3	4
Annual cost	Dollars	3,315	3,315	2,652	2,652	2,652	2,652	1,989	1,989	2,652
Cost per ton	Dollars	.04	.04	.03	.03	.03	.03	.02	.02	.03
Maintenance										
Labor per day	Man-hours	20	22	22	20	22	22	22	23	22
Annual cost	Dollars	14,820	16,302	16,302	14,820	16,302	16,302	16,302	17,043	16,302
Cost per ton	Dollars	.19	.21	.21	.19	.21	.21	.21	.22	.21
Total										
Labor per day	Man-hours	68	114	162	76	122	170	74	121	170
Annual cost	Dollars	46,644	77,298	109,122	51,948	82,602	114,426	50,778	82,017	114,426
Cost per ton	Dollars	.60	1.11	1.40	.66	1.16	1.46	.72	1.24	1.54
Supervisor										
Labor per day	Man-hours	20	22	22	20	22	22	22	23	22
Annual cost	Dollars	16,120	17,732	17,732	16,120	17,732	17,732	17,732	18,538	17,732
Cost per ton	Dollars	.21	.23	.23	.21	.23	.23	.23	.24	.23

Table 30.--Man-hours required at various levels of production in model feed plants

Model size	Production levels	Tons produced	Method of operation								
			A	B	C	D	E	F	G	H	I
	Percent	Tons	Man-hours								
80 tons	100	80	40	56	72	48	64	80	48	64	80
	80	64	32	48	64	40	56	64	40	56	64
	60	48	24	40	48	32	48	48	32	48	48
	40	32	16	32	32	24	32	32	24	32	32
100 tons	100	100	40	64	80	56	72	88	48	72	88
	80	80	32	56	72	48	64	72	40	64	72
	60	60	24	48	56	40	48	56	32	48	56
	40	40	16	40	40	32	40	40	24	40	40
150 tons	100	150	56	88	112	64	96	120	64	96	120
	80	120	48	80	96	56	80	104	56	80	104
	60	90	40	64	80	48	64	88	48	64	88
	40	60	32	48	64	40	48	64	40	48	64
200 tons	100	200	72	112	144	80	120	152	80	120	152
	80	160	64	96	104	64	96	128	64	96	128
	60	120	56	72	96	56	80	104	56	80	104
	40	80	48	56	72	48	56	80	48	56	80
250 tons	100	250	80	128	168	88	136	176	88	136	176
	80	200	64	120	136	80	120	152	80	120	152
	60	150	48	96	120	72	96	120	72	96	120
	40	100	40	72	88	48	72	96	48	72	96
300 tons	100	300	88	136	184	96	144	192	96	144	192
	80	240	72	120	168	80	120	168	80	120	168
	60	180	56	104	144	72	104	144	72	104	144
	40	120	48	72	104	64	72	104	64	72	104

APPENDIX C

BASIC EQUIPMENT IN MODELS

Basic equipment for the models in the six sizes analyzed is shown in tables 31-36. Equipment in the receiving, processing, and mixing centers is the same for each operation of a particular size model. Major differences arise in rearrangement of equipment to satisfy the varying requirements of each operation.

For example, pelleting equipment as shown in the tables would be sufficient to handle the pelleting needs of operations D, E, and F. However, this equipment has more than the capacity needed in operations G, H, I, where only 50 percent of the plant's output is pelleted. In operations A, B, and C, no pelleting equipment is needed since none of the output is pelleted.

Packing and warehousing equipment would also change with the operation. The equipment listed in the tables has sufficient capacity to handle the total output of the models regardless of variations in operations.

Equipment listed in the tables would be capable of producing 10 percent more than the specified output. This 10-percent overcapacity is recommended for all cost centers in all plants if their performance is to be fully efficient. More than 10 percent is uneconomical, especially if it exists in some of a plant's cost centers but not in others. Many plants, particularly older ones built 30 or more years ago, do have excessive capacity in some centers; sometimes as a result of a change in the mills' operations.

APPENDIX D

FEASIBILITY OF A SECOND SHIFT

There are varying opinions in the feed manufacturing industry concerning the feasibility of operating a plant for more than one 8-hour shift a day. Management may not be willing to operate more than one shift for several reasons. Frequently, a plant does not require a full second shift. Pelleting may be the bottleneck in a particular mill and therefore only one or two men are required on the second shift. With this situation management is confronted with problems: (1) Is a night supervisor needed? (2) Can this skeleton crew remain flexible and perform several types of operation during their 8 hours of work? (3) Will the production requirements remain high enough throughout the year to warrant the additional crew?

Another disadvantage is obtaining personnel for a night shift. Even though a higher rate is paid to night workers, skilled personnel are not always available. Night shift personnel should be more highly trained than dayworkers since they may be called upon to make decisions which would be made by supervisors on the day shift. Some plants have overcome some of their production problems by reducing the number of workers on the first shift, and having two

Table 31.--Basic equipment in 80-ton model feed plant

	Number	Horsepower (each motor)	Size or capacity
Receiving:			
Truck hoist	1	10	8 tons
Power shovel	1	3	--
Conveyor, drag	1	15	10" x 55'
Elevator, bucket	1	10	12" x 60'
Scalper (grain & soft feed)	1	1/2	40 tons per hour
Automatic scale w/surge gin	1	--	5,000 lb.
Elevator, bucket	1	15	12" x 100'
Conveyor, drag	1	5	12" x 15'
Distributors	2	1/4	6 & 12 hole
Storage tanks	2	--	5,000 gal.
Processing:			
Feeder	1	1/2	18"
Hammermill	1	75(& 30-hp. fan)	18", 8 tons per hour
Distributor	1	1/4	6 hole
Mixing:			
Feeder screws	15	39	--
Tank scale	1	--	5,000 lb.
Scale hopper	1	--	5,000 lb.
Batch controls	1	--	Semiautomatic
Horizontal mixer w/surge bin	1	20	2 tons
Elevator, bucket	1	5	12" x 45'
Scalper, finished feed	1	1/2	15 tons per hour
Elevator, bucket	1	5	12" x 60'
Distributor	1	1/4	8 hole
Fat system, complete	1	3	40 gal. per minute
Molasses system, complete	1	3	12 gal. per minute
Continuous mixer	1	10	15 tons per hour
Conveyor, drag	1	2	12" x 10'
Pelleting:			
Pellet mill	1	100	10-14 tons per hour
Cooler	1	15	10-14 tons per hour
Crumbler	1	10	10-14 tons per hour
Scalper	1	1/2	10-14 tons per hour
Elevator, bucket	2	1 & 2	6" x 35'; 10" x 8'
Distributor	1	1/4	8 hole
Packing:			
Packing scale	1	--	Automatic, 13 50-lb. bags per min.
Bag conveyor	1	3/4	--
Sewing machine	1	1/3	--
Warehousing:			
Forklift	1	--	3,000 lb.
Traveling weigh hopper	1	1	3 tons
Conveyor, drag	1	5	12" x 30'
Miscellaneous:			
Boiler	1	--	60 hp
Air compressor	1	15	--

Table 32.--Basic equipment in 100-ton model feed plant

Equipment	Number	Horsepower (each motor)	Size or capacity
Receiving:			
Truck hoist	1	10	8 tons
Power shovel	1	3	--
Conveyor, drag	1	15	10" x 55'
Elevator, bucket	1	10	12" x 60'
Scalper (grain & soft feed)	1	1/2	40 tons per hour
Automatic scale w/surge bins	1	--	5,000 lb.
Elevator, bucket	1	15	12" x 100'
Conveyor, drag	1	5	12" x 15'
Distributors	2	1/4	6 & 12 hole
Storage tanks	2	--	5,000 gal.
Processing:			
Feeder	1	1/2	18"
Hammermill	1	75 (& 30-hp. fan)	18", 8 tons per hour
Distributor	1	1/4	6 hole
Mixing:			
Feeder screws	15	39	--
Tank scale	1	--	5,000 lb.
Scale hopper	1	--	5,000 lb.
Batch controls	1	--	Semiautomatic
Horizontal mixer w/surge bin	1	20	2 tons
Elevator, bucket	1	5	12" x 45'
Scalper, finished feed	1	1/2	15 tons per hour
Elevator, bucket	1	5	12" x 60'
Distributor	1	1/4	8 hole
Fat system, complete	1	3	40 gal. per minute
Molasses system, complete	1	3	12 gal. per minute
Continuous mixer	1	10	15 tons per hour
Conveyor, drag	1	2	12" x 10'
Pelleting:			
Pellet mill	1	125	14-18 tons per hour
Cooler	1	15	14-18 tons per hour
Crumbler	1	10	14-18 tons per hour
Scalper	1	1/2	14-18 tons per hour
Elevator, bucket	2	1 & 2	6" x 35' & 10" x 80'
Distributor		1/4	8 hole
Packing:			
Packing scale	1	--	Automatic, 13 50-lb. bags per minute
Bag conveyor	1	3/4	--
Sewing machine	1	1/3	--
Warehousing:			
Forklift	1	--	3,000 lb.
Traveling weigh hopper	1	1	3 tons
Conveyor, drag	1	5	12" x 30'
Miscellaneous:			
Boiler	1	--	75 HP
Air compressor	1	15	--

Table 33.--Basic equipment in 150-ton model feed plant

Equipment	Number	Horsepower (each motor)	Size or capacity
Receiving:			
Truck hoist	1	10	8 tons
Power shovel	1	3	--
Conveyor, drag	1	15	10" x 65'
Elevator, bucket	1	10	12" x 70'
Scalper (grain & soft feed)	1	1/2	40 tons per hour
Automatic scale w/surge bins	1	--	5,000 lb.
Elevator, bucket	1	15	12" x 110'
Conveyor, drag	1	5	12" x 20'
Distributors	2	1/4	6 & 12 hole
Storage tanks	2	--	5,000 gal.
Processing:			
Feeder	1	1/2	24"
Hammermill	1	100 with pneumatic system-negative 50	24", 13 tons per hour
Distributor	1	1/4	6 hole
Mixing:			
Feeder screws	15	44	--
Tank scale	1	--	7,000 lb.
Scale hopper	1	--	7,000 lb.
Batch controls	1	--	Semiautomatic
Horizontal mixer w/surge bin	1	25	3 tons
Elevator, bucket	1	5	12" x 50'
Scalper, finished feed	1	1	30 tons per hour
Elevator, bucket	1	5	12" x 74'
Distributor	1	1/4	8 hole
Fat system, complete	1	3	40 gal. per minute
Molasses system, complete	1	3	12 gal. per minute
Continuous mixer	1	10	15 tons per hour
Conveyor, drag	1	2	12" x 20'
Pelleting:			
Pellet mill	2	75 & 125	6-10 & 14-18 tons per hour
Cooler	2	10 & 15	6-10 & 14-18 tons per hour
Crumbler	2	10	6-10 & 14-18 tons per hour
Scalper	2	1/2	6-10 & 14-18 tons per hour
Elevator, bucket	2	2 & 3	6" x 40 & 10" x 95'
Distributor	1	1/4	8 hole
Packing:			
Packing scale	1	--	Automatic, 16 50-lb. bags per minute
Bag conveyor	1	3/4	--
Sewing machine	1	1/3	--
Warehousing:			
Forklift	1	--	3,000 lb.
Traveling weigh hopper	1	1	3 tons
Conveyor, drag	1	5	12" x 30'
Miscellaneous:			
Boiler	1	--	100 HP
Air compressor	1	15	--

Table 34.--Basic equipment in 200-ton model feed plant

Equipment	Number	Horsepower (each motor)	Size or capacity
Receiving:			
Truck dump, platform scale	1	25	50' x 10' (50 tons)
Power shovels	2	2	--
Conveyor, drag	1	7 1/2	12" x 60'
Elevator, bucket	1	10	10' x 100'
Scalper (grain & soft feed)	1	1	40 tons per hour
Automatic scale w/surge bins	1	--	5,000 lb.
Elevator, bucket	1	15	12" x 120'
Conveyors, drag	2	7 1/2	16" x 40' & 16" x 30'
Distributors	2	1/4	6 & 12 hole
Capstan car puller	1	7 1/2	--
Storage tanks	2	--	5,000 gal.
Processing:			
Feeder	2	1/2	18"
Hammermill	2	75 & 30	18", 15 tons per hour
Distributor	2	1/4	6 hole
Mixing:			
Feeder conveyors	18	56	--
Tank scale	1	--	7,000 lb.
Scale hopper	1	--	7,000 lb.
Batch controls	1	--	Automatic
Horizontal mixers w/surge bins	1	25	3 tons
Conveyor, drag	1	3	9" x 20'
Elevator, bucket	1	5	12" x 50'
Hammermill, feed dresser	1	30	14"
Scalper	1	1	30 tons per hour
Elevator, bucket	1	7 1/2	12" x 70'
Distributor	1	1/2	12 hole
Fat system, complete	1	3	50 gal. per minute
Molasses system, complete	1	3	20 gal. per minute
Continuous mixer	1	20	25 tons per hour
Conveyor, drag	1	2	12" x 20'
Pelleting:			
Pellet mill	2	125	14-18 tons per hour
Cooler	2	15	14-18 tons per hour
Crumbler	2	10	14-18 tons per hour
Scalper	2	1	14-18 tons per hour
Elevator, bucket	4	2 at 5 and 2 at 2	2 at 6" x 90' and 2 at 6" x 40'
Distributor	2	1/2	8 hole
Packing:			
Auto-packing scale belt feeder	1	2	Automatic 20 50-lb bags per minute
Bag conveyor	1	3/4	--
Sewing machine	1	1/3	--
Impacker	1	3/4	--
Warehousing:			
Forklift	1	--	4,000 lb.
Conveyor, drag	1	7 1/2	16" x 30'
Platform scales	1	--	50' x 10' (50 tons)
Miscellaneous:			
Boiler	1	--	150 HP
Air compressor	1	15	--

Table 35.--Basic equipment in 250-ton model feed plant

Equipment	Number	Horsepower (each motor)	Size or capacity
Receiving:			
Truck dump, platform scale	1	25	50' x 10' (50 tons)
Power shovels	2	4	
Conveyor, drag	1	7 1/2	12" x 60'
Elevator, bucket	1	10	10" x 100'
Scalper (grain & soft feed)	1	1	40 tons per hour
Automatic scale w/surge bins	1		5,000 lb.
Elevator, bucket	1	15	12" x 120'
Drag conveyors	2	7 1/2	16" x 50' and 16" x 30'
Distributors	2	1/2	6 & 12 hole
Capstan car puller	1	7 1/2	
Storage tanks	2		5,000 gal.
Processing:			
Feeder	2	1/2	24"
Hammermill	2	100	24", 26 tons per hour
Pneumatic conveying system	2	50	--
Distributor	2	1/2	6 hole
Mixing:			
Feeder conveyors	18	56	--
Tank scale	1	--	5,000 lb.
Scale hopper	1	--	5,000 lb.
Batch controls	1	--	Automatic
Horizontal mixers w/surge bins	2	20	2 tons
Conveyor, drag	2	3	9" x 20'
Elevator, bucket	2	5	12" x 60'
Hammermill, feed dresser	1	30	14"
Scalper	1	1	40 tons per hour
Elevator, bucket	1	7 1/2	12" x 100'
Distributor	1	1/2	12 hole
Fat system, complete	1	3	50 gal. per minute
Molasses system, complete	1	3	20 gal. per minute
Continuous mixer	1	20	30 tons per hour
Conveyor, drag	1	3	12" x 15'
Pelleting:			
Pellet mill	3	100	10-14 tons per hour
Cooler	3	10	10-14 tons per hour
Crumbler	3	10	10-14 tons per hour
Scalper	3	1/2	10-14 tons per hour
Elevator bucket	4	2 at 5 and 2 at 2	2 at 6" x 90' 2 at 6" x 40'
Distributor			
Packing:			
Auto-packing scale belt feeder	2	2	Automatic 16 50-lb. bags per minute
Bag conveyor	2	3/4	--
Sewing machine	2	1/3	--
Impacker	1	3/4	--
Warehousing:			
Forklift	1	--	4,000 lb.
Conveyor, drag	1	7 1/2	16" x 30'
Platform scales	1	--	50' x 10' (50 tons)
Miscellaneous:			
Boiler	1	--	150 HP
Air compressor	1	20	--

Table 36.--Basic equipment in 300-ton model feed plant

Equipment	Number	Horsepower (each motor)	Size or capacity
Receiving:			
Truck dump, platform scale	1	25	50' x 10' (50 tons)
Power shovels	2	4	
Conveyor, drag	1	10	12" x 70'
Elevator, bucket	1	15	10" x 110'
Scalper (grain & soft feed)	1	1	50 tons per hour
Automatic scale w/surge bins	1		5,000 lb.
Elevator, bucket	1	15	12" x 120'
Conveyors, drag	2	7 1/2	16" x 50 & 16" x 35'
Distributors	2	1/2	6 & 12 hole
Capstan car puller	1	7 1/2	
Storage tanks	2		8,000 gal.
Processing:			
Feeder	2	1/2	24"
Hammermill	2	100	24", 26 tons per hour
Pneumatic conveying system	2	50	--
Distributor	2	1/2	6 hole
Mixing:			
Feeder conveyors	18	60	--
Tank scale	1	--	7,000 lb.
Scale hopper	1	--	7,000 lb.
Batch controls	1	--	Automatic
Horizontal mixers w/surge bins	2	25	3 tons
Conveyor, drag	2	3	9" x 20'
Elevator, bucket	2	5	12" x 60'
Hammermill, feed dresser	1	30	14"
Scalper	1	1	50 tons per hour
Elevator, bucket	1	7 1/2	12" x 100'
Distributor	1	1/2	12 hole
Fat system, complete	1	3	50 gal. per minute
Molasses system, complete	1	3	20 gal. per minute
Continuous mixer	1	20	30 tons per hour
Conveyor, drag	1	3	12" x 20'
Pelleting:			
Pellet mill	3	125	14-18 tons per hour
Cooler	3	15	14-18 tons per hour
Crumbler	3	10	14-18 tons per hour
Scalper	3	1	14-18 tons per hour
Elevator, bucket	6	3 at 5 and 3 at 2	3 at 6" x 90' and 3 at 6" x 40'
Distributor	3	1/4	8 hole
Packing:			
Auto-packing scale belt feeder	2	2	Automatic 20 50-lb. bags per minute
Bag conveyor	2	3/4	--
Sewing machine	2	1/3	--
Impacker	1	3/4	--
Warehousing:			
Forklift	2	--	3,000 lb.
Conveyor, drag	1	10	16" x 40'
Platform scales	1	--	50' x 10' (50 tons)
Miscellaneous:			
Boiler	1	200	--
Air compressor	1	20	--

shifts with the same number of workers and responsibilities. In general, feed manufacturers find the cost per ton to be higher and man-hour efficiency lower on a second shift.

Several arguments are given by mill management in justification of more than one shift. One is economics of operation. A plant is designed and built under certain assumptions to produce a set number of tons per hour and to operate at certain fixed costs.

Fixed costs go on regardless of volume of output and are therefore lower per unit of output at a higher volume of output. Major fixed costs are (1) depreciation, interest, insurance, and taxes, and (2) fixed overhead expense of salaried employees and other administrative costs.

Fixed facility and equipment costs per unit of output are lowest when these facilities are operated at capacity. For example, a feed manufacturer's fixed cost (depreciation, interest, insurance, and taxes) per ton of feed will be at a minimum when the plant is operated at full capacity 24 hours a day, 365 days a year. The more nearly this full capacity of facilities and equipment is approached, the lower will be these fixed costs per unit. However, the total cost per ton of feed may not be at the minimum when operating this way.

Other fixed costs (administrative or management) can often be reduced per unit by spreading them over a greater volume. It is more difficult to reduce this type of fixed cost than those discussed above. Reductions in cost which result in reductions in productivity are false economy. However, it is frequently possible to assign routine jobs to lower paid employees without loss of managerial efficiency. Managerial overhead costs per unit of volume can be reduced accordingly.

Variable costs are those costs which increase in total (but not necessarily proportionately) as output increases. Variable costs include (1) labor costs, (2) maintenance and repairs, (3) utilities, (4) plant supplies, and (5) miscellaneous. Each of these contributes to the total unit operating cost.

However, some of these cost items increase proportionately, or nearly so, with increase in output. Some may even increase more than proportionately while others increase only slightly with increases in output. While some reductions in these variable costs per unit of volume usually can be realized by increases in output, relatively the greatest opportunities for reductions lie in reducing them in total.

The most important variable costs are labor and utility costs. Labor costs include the wages of hourly employees, including overtime wages, and associated costs included as fringe benefits. Probably the major opportunity for reducing these costs per unit of volume lies in increasing the productivity of the worker by increasing efficiency of plant layout, training workers to use efficient work methods, and the like.

Table 37.--Operating costs per ton for all model feed plants working 16 hours per day: Fixed, variable, and total

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
80 tons:									
Fixed	1.13	1.24	1.20	1.32	1.40	1.37	1.27	1.38	1.35
Variable	2.56	3.28	3.64	3.32	4.02	4.39	3.32	4.02	4.38
Total	3.69	4.52	4.84	4.64	5.42	5.76	4.59	5.40	5.73
100 tons:									
Fixed	1.04	1.13	1.10	1.24	1.32	1.30	1.16	1.24	1.22
Variable	2.22	3.16	3.31	3.12	3.75	3.98	2.78	3.63	3.87
Total	3.26	4.29	4.41	4.36	5.07	5.28	3.94	4.87	5.09
150 tons:									
Fixed	.86	.93	.92	1.01	1.08	1.06	.94	1.02	.99
Variable	1.94	2.71	2.98	2.54	3.33	3.58	2.41	3.19	3.43
Total	2.80	3.64	3.90	3.55	4.41	4.64	3.35	4.21	4.42
200 tons:									
Fixed	.80	.87	.84	.93	1.00	.96	.90	.96	.94
Variable	1.83	2.54	2.81	2.39	3.13	3.38	2.28	3.00	3.27
Total	2.63	3.41	3.65	3.32	4.13	4.34	3.18	3.96	4.21
250 tons:									
Fixed	.76	.84	.82	.89	.96	.94	.87	.94	.90
Variable	1.67	2.38	2.63	2.27	2.92	3.19	2.12	2.79	3.05
Total	2.43	3.22	3.45	3.16	3.88	4.13	2.99	3.73	3.95
300 tons:									
Fixed	.72	.79	.76	.84	.90	.88	.80	.86	.84
Variable	1.59	2.18	2.45	2.14	2.70	3.00	1.98	2.58	2.84
Total	2.31	2.97	3.21	2.98	3.60	3.88	2.78	3.44	3.68

Total operating costs for the models working 16 hours a day are summarized in table 37, which should be compared with table 16. Total costs for a 16-hour operation are between 75 to 80 percent of the 8-hour operating cost. In model 80-F, the high-cost operation, operating the model for two shifts will reduce costs from $7.13 to $5.76 a ton. Operating costs in model 300-F will be reduced from $4.74 to $3.88 a ton. In operations where the finished feed is pelleted or bagged there appears to be less saving. However, savings do account for about 20 percent reduction in the per ton cost.

It is impossible to say that all plants should or should not use more than one shift. Each plant's situation and production problems are different. Therefore management is charged with this decision and it must be made on factors at hand. Management should look very closely at the savings possible through a two-shift operation. As mentioned earlier, as plant utilization approaches capacity the per unit cost is decreased.

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